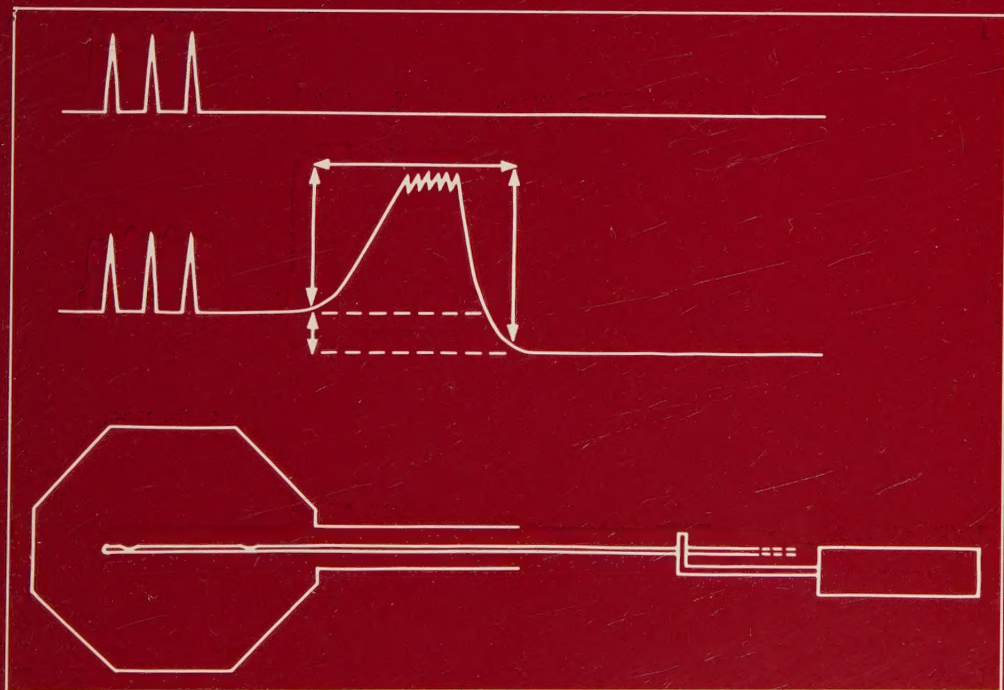


Incidence and Pathophysiology of Urinary Incontinence in Women

by

Constantin Serafim Iosif



Lund 1981



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From the Department of Obstetrics and Gynecology, University
Hospital, Lund, Sweden

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Lund 1981

Dedicated to my wife Elena, and to Victor and Robert

The present thesis is based on the following papers

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| I | Iosif, S., Henriksson, L., and Ulmsten, U.: The frequency of disorders of the lower urinary tract, urinary incontinence in particular, as evaluated by a questionnaire survey in a gynecological health control population. <i>Acta Obstet Gynecol Scand</i> 60: 71-76, 1981. | 49 |
| II | Iosif, S., Henriksson, L., and Ulmsten, U.: Urethrocystometry as a routine method for the objective evaluation of women with urinary incontinence. <i>Arch Gynecol</i> 230: 41-47, 1980. | 55 |
| III | Iosif, S.: Stress incontinence during pregnancy and in puerperium. <i>Int J Gynaecol Obstet</i> 19/1: 13-20, 1981. | 63 |
| IV | Iosif, S., Henriksson, L., and Ulmsten, U.: Postpartum incontinence. <i>Urol Int</i> , 1981. In press. | 77 |
| V | Iosif, S., Ingemarsson, I., and Ulmsten, U.: Urodynamic studies in normal pregnancy and in puerperium. <i>Am J Obstet Gynecol</i> 137: 696-700, 1980. | 86 |
| VI | Iosif, S. and Ulmsten, U.: Comparative urodynamic studies of continent and stress incontinent women in pregnancy and in puerperium. <i>Am J Obstet Gynecol</i> , 1981. In press. | 91 |

In the text the papers are referred to by their Roman numerals.

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HISTORY

Women seem to have been troubled by urinary incontinence since the beginning of time. The earliest evidence of this is the mummy Henhenith, one of the six women of Menunhotep II of the 11th dynasty who ruled Egypt prior to 2050 BC. Her mummy was discovered in 1935 and radiography disclosed an extensive urinary fistula. Urinary problems are also described in the Kahun papyrus, approximately 2000 BC, and in Eber's papyrus, 1550 BC (from Robertson 1978).

Toward the latter part of the 19th century more detailed reports of treatment of urinary incontinence began to appear. In 1870-71, Corrigan and Espagne described various methods of hydrotherapy in treating urinary incontinence: a 5-minute foot bath in cold water, a cold hypogastric shower for 5 to 10 seconds, an aromatic bath, and a vaginal douche. Schatz recommended in 1877 epidural injections of sterile water or saline solution and vaginal tampons and suppositories. Neveu (1880) suggested ligature of the prepuce as surgical treatment of urinary incontinence with application of compresses to the external urethral meatus. Among the pharmaceuticals recommended during the 1800's were ergotamine, belladonna, strychnine, and cantharides.

More modern and extensive surgical treatment of urinary incontinence began to take form at the end of the 1800's. German and French surgeons turned their attention at that time to surgical reconstruction of the urethra and the anterior vaginal wall. Different methods were described by Frank (1882), Pawlick (1883), Winkel (1886), Engström (1887), and Gersuny (1898). In 1907, Giordano introduced sub-urethral slings, and in 1914, Kelly advised bladder neck sutures in treating urinary incontinence. Between 1907 and 1932 the sling epoch blossomed in Germany through such famed surgeons as Goebell, Frangenheim, Stoeckel, and Martius. In 1923 Bonney described suspension operations involving ventral fixation of the bladder. In 1933, Price described the fascia lata band, and in 1942, Aldrige reported treatment of urinary incontinence using a rectus abdominalis fascia sling. In 1949, Krantz, Marshall, and Marchetti published their abdominal urethrocystopexi technique. These operating methods have since been imitated and modified, and there are at present descriptions of approximately 120 different methods of treatment of urinary incontinence (Henriksson 1977).

Incidence

While various more or less advanced techniques for the treatment of urinary incontinence are described in the literature, far less consideration seems to have been given to the incidence or frequency of occurrence of this condition. More disturbing is the fact that poor selection of material and inadequate definition of objec-

tives have reduced the value of the data presented in many investigations. Thus, the inquiries have often concerned themselves with specific population groups as, for example, young college girls, nurses, or the like. Most often objective methods of investigation have not been employed, and the manner in which the patient has been questioned has frequently been omitted. Among the frequency studies of urinary incontinence, Nemir's and Middleton's investigation of 1954 may be mentioned. These authors found a 52 % incidence of stress incontinence in a group of 1320 college girls. Ninety-five percent of these showed superficial and intermittent stress incontinent symptoms while 5 % indicated manifest stress incontinence. Kellar (1956) interviewed 134 nurses, 65 % of whom indicated stress incontinence. Francis 1960, in his frequency investigation of 400 pregnant females (222 I-pregnancies; 178 multi-pregnancies), found a 67 % incidence of stress incontinence during pregnancy but no onset of stress incontinence in the puerperium. Beck, in 1965, found a 31.3 % incidence of stress incontinence among 1000 out-patients taken at random. In 13.7 % the symptoms first appeared prior to pregnancy; in 64 % during pregnancy, and in 14 % in the puerperium. Only 2.6 % reported onset of the symptoms in connection with menopause. Wolin (1969) interviewed 4211 student nurses in an inquiry dealing with urinary disturbances. Fifty-one percent reported urinary incontinence, of which 32 % experienced persistent distress. In 1967, Osborne published the results of an inquiry among 600 female chain-store employees between the ages of 36 and 60. He found a stress incontinence frequency of 26 % in these women and observed that the difficulty did not increase in frequency with age. In a random study of women over 65 years of age Yarnell and Leger 1979 reported a 17 % incidence of urinary incontinence.

It is evident from the above that there is a wide range of discrepancy among the various investigators as to the frequency of urinary incontinence. This is undoubtedly due to the fact that the respective investigators have had different population groups under study in their investigations and have employed varying techniques. In addition, the incontinent condition has seldom been conclusively documented. Still missing is an investigation, carried out in an epidemiologically well-defined area, where the frequency of the dysfunction is studied in an entire population group with a reasonably even age distribution. It would also be highly desirable to establish, on the basis of such a study the extent to which the patients' subjective narrative about her experience of urinary incontinence compared to objective measurements, subsequently the type of prevailing incontinence.

The effects of pregnancy and childbirth upon the lower urinary tract

The effects of pregnancy and childbirth upon the lower urinary tract were studied as early as the latter part of the 19th century. In 1872, in his Atlas of Topographical Anatomy, Braun described the altered position of the bladder during pregnancy and delivery (section of two frozen corpses; one deceased in late pregnancy, the other during childbirth).

In 1884, Holliday Croom described in his monography "The Bladder During Parturition", the position of the bladder in non-pregnant women, in early and late pregnancy, and during delivery. Among other observations, he concluded that the urethra became extended during delivery. In 1929, Schubert published X-ray studies of the bladder during pregnancy and delivery. He considered that the bladder became an intra-abdominal organ before the presenting part of the infant became engaged in the pelvis minor.

Malpas, Jeffcoate and Lister (1949) investigated the bladder and urethral displacement during labor. Initially, no displacement of the bladder base could be observed but the movement of the presenting part brought about an upward and forward movement of the bladder base until it became aligned with the urethra. The degree of displacement was dependent upon the relative sizes of the presenting part and the pelvic cavity. If the space was greatly confined the bladder base could come up to the top of the pubis. The authors concluded that the essential lesion in stress incontinence might be due to an inability of the bladder fascia to regain its tone.

In 1960, Francis examined 83 pregnant women (50 continent and 33 stress incontinent) by urethrocytography. He found a reduced bladder capacity during the final weeks of pregnancy after the head of the infant had entered the pelvis minor. The absence of the urethrovesical angle in pregnant incontinent women was also recorded. Clow, in 1975, investigated by urethrocytometry the effect of the position of the body upon the functions of the bladder and the urethra in normal and stress incontinent pregnant women. In his preliminary report he demonstrated that a change in the position of the body from supine to standing accentuated detrusor instability and/or sphincter insufficiency in stress incontinent pregnant women.

These studies point to the effects of pregnancy and delivery upon the lower urinary tract. There is, however, a need for more systematic comparative studies, primarily studies which employ sophisticated techniques, to penetrate the question of how vital continence parameters undergo change during pregnancy. The use of certain X-ray techniques would undoubtedly be extremely helpful in this respect but in view of the radiation risk to the mother and the

fetus, such techniques can hardly be used during pregnancy.

METHODS USED IN EVALUATING URINARY INCONTINENCE

Case history is the simplest and one of the most important methods of assessing urinary incontinence. It can not, however, distinguish between certain etiological factors underlying the urinary incontinence symptom.

Clinical examination with observation of urinary leakage should always include vaginal examination and Bonney's test and a simple neurological examination.

X-ray studies

Micturition urethrocystography. Jeffcoate and Roberts 1952 were the first to emphasize the importance of the presence of a posterior urethrovesical angle in the radiologic picture of normal continence. They pointed out the significance of a flattened urethrovesical angle in the appearance of stress incontinence. Angle investigations of this nature were made under micturition urethrocystography. The bladder neck (the vesico-urethral area) in continent women lies in the lower third of the pubis. This area is displaced under pressure downward and rearward by 0.5 to 1.5 cm according to age and the anatomically functional integrity of the lower pelvis. In young active women with a normal lower pelvis, the vesico-urethral mobility is limited to 0.5 cm (Tanagho 1974). In older continent women with a comparatively relaxed pelvis, the decline of the vesico-urethral area is greater, up to 1.5 cm (Tanagho 1974).

In 1953, Hodgkinson was able to confirm many earlier findings with respect to urethral and bladder position in relation to the symphysis pubis in normal nulliparous and multiparous females. He observed the downward and rearward bladder movement which accompanies straining, and which serves to assimilate the internal urethral meatus into the anterior bladder wall.

In 1956, Bailey described seven different anatomical variations of defective urethrovesical angles in urinary incontinence, while Greenwald (1967) showed that 93 % of patients with incontinence display a normal micturition urethrocystography. The same author found that no less than 65 % of healthy continent patients have an abnormal micturition urethrocystography (MUCG). Schapiro and Drutz (1979) have shown that 82 % of continent women have a defective MUCG. This would indicate that the MUCG can hardly be used in diagnostics of genuine stress incontinence. Abnormal mobility of the vesico-urethral segment does not provide absolute assurance that the patient suffers from stress incontinence; neither does the

absence of an abnormal mobility of the vesico-urethral angle guarantee that the patient is continent.

Simultaneous video-pressure-flow cystourethrography. This technique was described by Miller and Tanagho in 1966 and applied clinically by Bates, Turner-Warwick and Whiteside in 1970, and by Bates and Corney in 1971. The various components which are used separately or in combination may be adapted individually for each patient. The technique is costly, requires qualified personnel, and is time-consuming. Filling and emptying of the bladder can be recorded on video tape for later analysis. By using an inclined table the effects of changes in position upon bladder functions can be studied.

Colpocystourethrography. In 1965, Bethoux described the colpocystogram as a new technique for examining prolapse and urinary incontinence, using X-ray contrast fluid in the bladder, vagina, uterus, and rectum. Nichols, Marsofsky, and Randall combined metal chain urethrocytography with barium colpography in 1973. The method was called urethrocolpography and permitted a simultaneous examination of the urogenital diaphragm, the pelvic diaphragm, and the perineum. Olesen described in 1977 combined colpocystourethrography with pressure flow measurement as a new method for diagnosis of bladder base insufficiency. He examined 420 patients and found bladder base insufficiency in 26.2 %, 84 % of which were stress incontinent.

Most of the methods discussed here involving X-ray techniques can undoubtedly furnish us with a good understanding of the parameters vital to maintaining continence. However, as mentioned at the beginning of this section the X-ray techniques can hardly be recommended for examining pregnant patients.

Endoscopy: Urethrocytscopy

It is of great importance that the various morphological changes in the lower urinary tract be charted in connection with an investigation into urinary incontinence. This is done most readily by means of urethrocytscopy. Several different techniques have been described, usually using water, physiological saline solution, or carbon dioxide, for infusion. Such conditions as urethritis, trigonitis, tumors, congenital anomalies, or urethral or bladder diverticula, can be diagnosed with the aid of endoscopic techniques. Urethrocytscopy is therefore an important technique to be used in examining urinary incontinent women. The method is, however, not designed to identify or grade the patient's urinary incontinence.

Urine flow measurements

Continence is the result of a dynamic state of balance between the detrusor activity and the closing mechanism of the urethra. Normal subjects have a urine flow, with an adequate bladder volume, of more than 15 ml per second. A malfunction of the urethra due to an increased resistance to flow can be measured during micturition. A diagnosis of urethral obstruction, employing endoscopy alone, is often incorrect. More recently cystometry has sometimes been combined with urine flow measurement. These methods are of great importance where there is an obstruction of the urethra because of prostate hyperplasia, for example. Where a functional obstruction of the urethra exists, a reduction of urine flow is registered at a normal bladder volume and urine retention is often clinically observed. This may be of importance if surgery for stress incontinence is contemplated.

Pressure measurements

The techniques which have mainly come into clinical use in evaluating the patients' type and degree of urinary incontinence are the various forms of pressure measurement. Certain techniques have been refined greatly in recent years as a result of the rapid developments in electronics. In some cases the measurements are carried out in the bladder or urethra only. In other cases, combined pressure measurements are made in the bladder and urethra simultaneously. Pressure measurements may also be combined with urine flow measurements.

Cystometry

A fundamental requirement in investigating urinary incontinence is a correct evaluation of the detrusor function. This may be achieved through cystometry, possibly in combination with measurement of the intra-abdominal pressure by means of an intra-rectal pressure registration. This is often combined with urine flow measurement as well. The examinations are usually carried out with the patients in supine position and using a relatively low rate of infusion; that is, physiological saline solution is injected into the bladder at a rate of 25 to 50 ml per minute. Arnold 1974 contends, however, that an instability of the bladder which he found in 58 % of the urinary incontinent patients will go unnoticed if these patients are not examined in the standing position as well as under cough provocation. In addition, a substantially higher rate of infusion is often used in these examinations, for example, 100 to 150 ml per minute. Ideally, the rate of filling should be comparable to the normal physiological situation in which case the filling is extremely slow compared to that used in clinical cystometry (see Klevmark 1978). For routine investigations, however, this is not very practical.

Urethrometry

During the 1960's there arose an interest in efforts to measure the sphincter function of the urethra in continent and incontinent women with the aid of intraluminal pressure recordings. Several different techniques came into use. Thus, in 1961, Enhörning employed a micro-balloon technique, while Brown and Wickham in 1969 utilized an open end catheter with constant flow. This latter technique was improved upon by Harrison and Constable in 1970 in such a way that the pressure in the urethra could be recorded at every point as the catheter was being drawn from the internal to the external meatus (urethral pressure profile measurement). These and similar techniques, however, impose considerable calibration problems, and pressure recording can be accompanied by considerable measurement artifact. This renders the above measurement technique less suitable for clinical routines or scientific studies where a certain amount of precision is desired.

In 1975 Asmussen and Ulmsten published a new technique for intra-urethral pressure measurements. They used microtransducers enclosed in a thin flexible dacron catheter. The advantage of this technique lies in the simplicity of calibration and its high sensitivity. Even though the microtransducer technique also involves certain technical problems, e.g., a catheter must still be inserted into the urethra, this method has proved to be superior to most other techniques for simultaneous urethrocystometry. Since this technique can be utilized for objective recording of essential continence parameters under varying conditions, changes in positions, different types of provocations, and in examining pregnant patients, it was decided to employ the microtransducer technique in this study.

PRESSURE RECORDING USED IN THE ACTUAL INVESTIGATION

Patients were examined in the lithotomy position and standing. The bladder was filled with warm physiological saline solution at a rate of ~50 ml per minute. Bladder and urethral pressure was recorded by means of a twin microtransducer catheter (Fig. 1). The urethral pressure profile was determined by inserting the catheter with the two microtransducers into the bladder and thereafter, the catheter was withdrawn at a constant speed (Fig. 2). The distal receptor records intravesical pressure continuously while the proximal receptor records the intraluminal pressure of the urethra at every point from the internal to the external meatus. Initially, three consecutive urethral profiles were taken, with a bladder content of 200 ml. These measurements allowed calculation of the maximum intraurethral pressure, the maximum intravesical pressure, the closure pressure, as well as the functional and absolute lengths of the urethra (See Fig. 2). Simultaneous urethrocystometry was

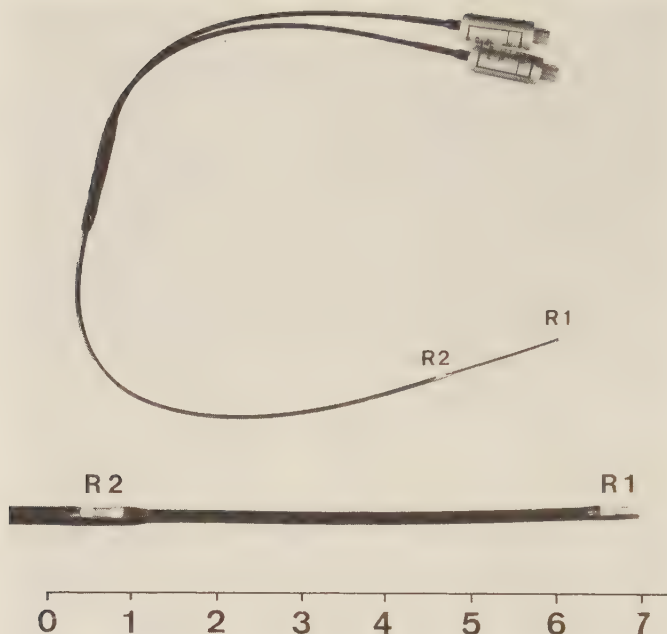


Fig. 1. The recording catheter with two microtransducers 6 cm apart. The lower part of the figure shows the tip of the catheter with the two microtransducers enlarged.

carried out with the proximal microtransducer placed within the high pressure zone of the urethra (Fig. 2). This examination can take place at any desired level of bladder volume, e.g., 100, 200, 300 ml, etc. It may also be performed under different types of provocation as, for example, having the patient to cough with a filled bladder, in supine and standing position. As shown in Fig. 3, a negative closure pressure may be observed in the absence of an increased detrusor contraction in a typical stress incontinent woman, while uninhibited detrusor contractions, prompted by cough provocation, can be seen in a patient with urge incontinence (Fig. 4).

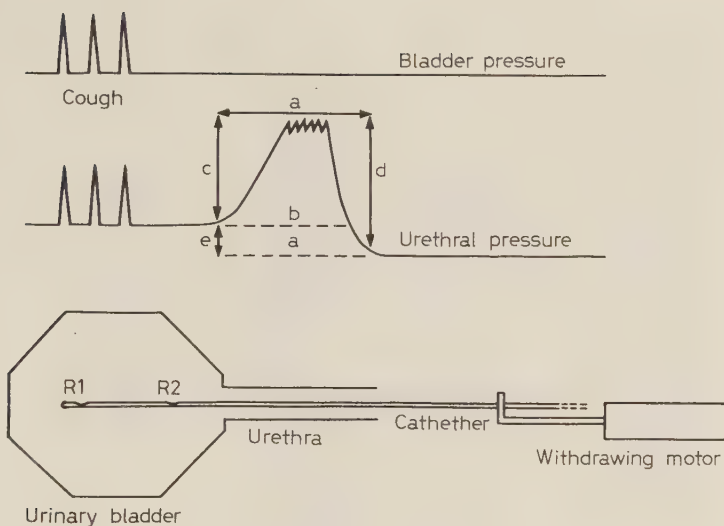


Fig. 2. Pressure recording technique and recorded parameters. The bladder and urethral pressures are recorded from two microtransducers, R1 and R2, attached to a Dacron catheter. Initially, both transducers are located within the bladder. Coughing indicates equal transmission of pressure from both transducers, as seen from the two tracings at the top of the figure. The catheter is then withdrawn at a constant speed, and thereby the urethral pressure profile is obtained. From this profile the following parameters can be calculated: (a) the absolute urethral length; (b) the functional urethral length; (c) the urethral closure pressure; (d) the maximum urethral pressure; and (e) the bladder pressure.

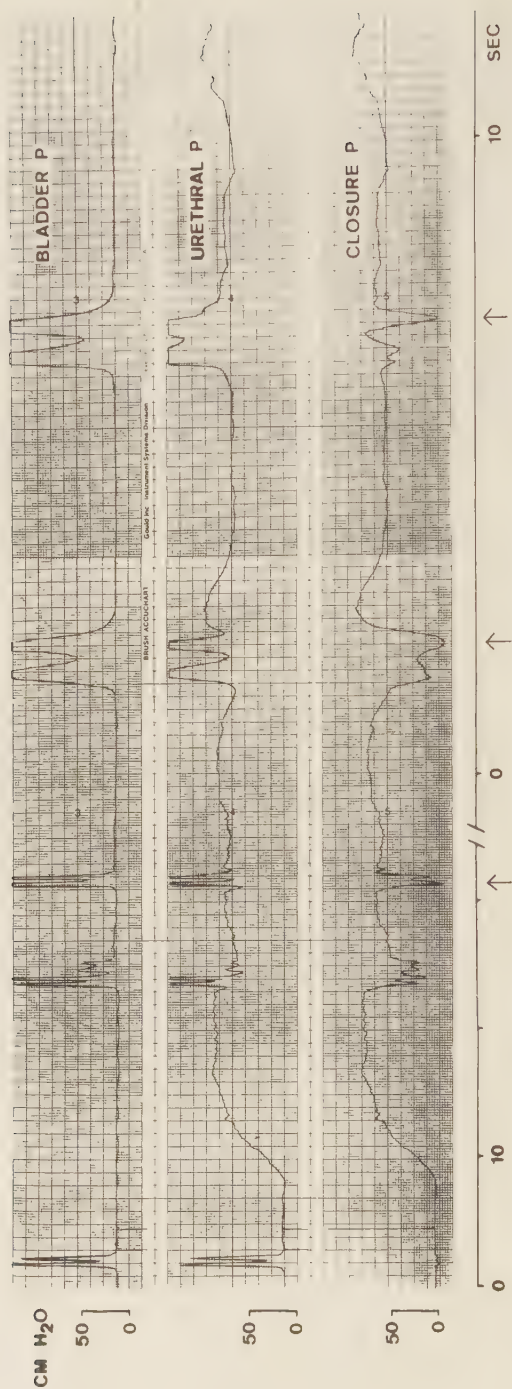


Fig. 3. Pressure diagram from one of the incontinent females. Upper tracing: bladder pressure; middle tracing: urethral pressure; lower tracing: urethral closure pressure. Negative closure pressure during coughing (cough indicated by arrows).

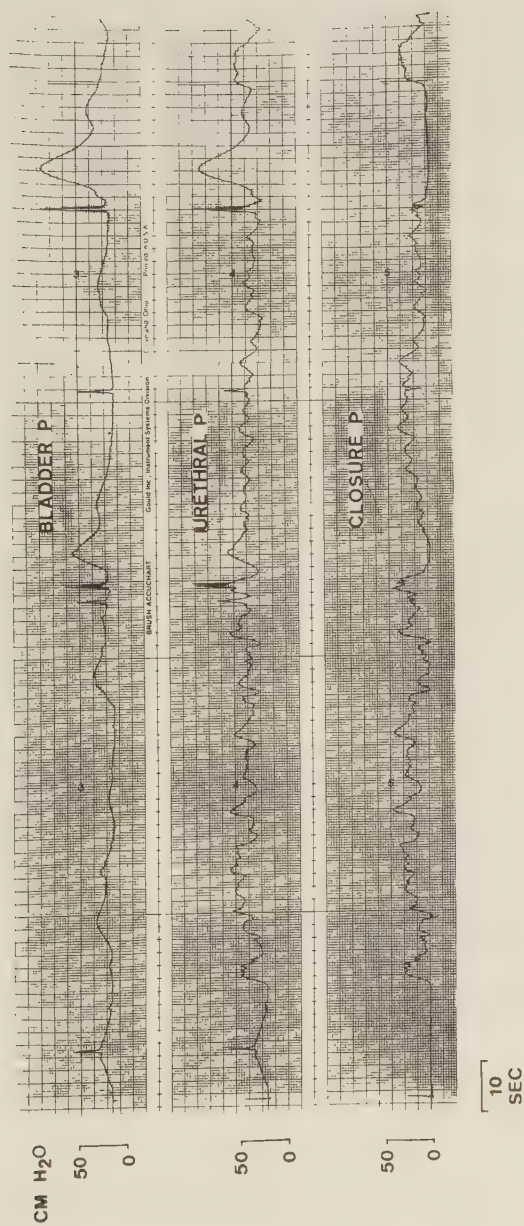


Fig. 4. Pressure tracings from one of the women with urge incontinence and instable bladder. Upper tracing: bladder pressure; middle tracing: urethral pressure; lower tracing: urethral closure pressure.

OBJECTIVES OF THE INVESTIGATION

The objectives of the current investigation have been:

1. To evaluate, using a questionnaire as an aid, the frequency of various types of urinary incontinence in a well-defined population.
2. To compare diagnoses of urinary incontinence as determined in out-patients with those determined in a urodynamic laboratory with access to electronic simultaneous urethrocystometry.
3. To determine the frequency of urinary incontinence during pregnancy and in puerperium.
4. To evaluate the role of pregnancy and delivery in the onset of stress incontinence.
5. To investigate by means of urethrocystometry possible changes in continence parameters among continent and stress incontinent women during pregnancy and in puerperium.

DEFINITIONS OF MEASURED PARAMETERS

Urethral pressure: the pressure within the urethra in relation to the atmospheric pressure.

Intravesical pressure: bladder pressure in relation to the atmospheric pressure.

Urethral pressure profile: continuous registration of the intra-urethral pressure from the internal to the external meatus.

Urethral closure pressure: the intraurethral pressure minus the bladder pressure.

Functional length of the urethra: that portion of the urethra where the intraluminal pressure exceeds the bladder pressure.

Absolute length of the urethra: that portion of the urethra where the intraluminal pressure exceeds the atmospheric pressure.

Urinary continence: absence of urine leakage combined with positive urethral closure pressure at moderate or forceful coughing (bladder pressure increase > 75 cm H₂O).

Stress incontinence: observed urine leakage and negative closure pressure (intravesical pressure exceeding the maximum intraurethral pressure) in the absence of abnormal detrusor activity.

Urge incontinence: involuntary loss of urine associated with a strong desire to void. Urge incontinence may be subdivided into motor urge incontinence, which can be associated with uninhibited detrusor contractions, and sensory urge incontinence which is not due to uninhibited detrusor contractions.

Lengths given in mm.

Pressures given in cm H₂O.

Rate of infusion: 50 ml per minute.

Definitions given are in general agreement with those recommended by I.C.S. in 1977 (Bates et al. 1977).

I

FREQUENCY OF URINARY INCONTINENCE ESTABLISHED WITH THE AID OF A QUESTIONNAIRE

Investigations on the frequency of urinary incontinence aided by questionnaires have been conducted by other clinics (Cardozo Stanton 1978). The intent has been to establish the role of case history with respect to differentiating the various types of urinary incontinence and to determine their frequency figures. The purpose of this investigation was to estimate the frequency of urinary incontinence and to appraise the value of questionnaires in diagnosis.

Material and methods

Of the 250,000 inhabitants of the municipality of Malmö, 5000 women are examined each year as part of the gynecological health control program. In this connection the women fill in a form which includes the question: Are you troubled by urinary difficulty? Of 4400 women who were examined under the program during the period August 1977 to June 1978, 944 answered this question affirmatively. Following the health control examination, the women who indicated that they suffered from urinary problems were provided with a questionnaire (See paper I, Figs. 1,2,3). The first page of the questionnaire dealt with stress incontinence, inquiring as to its extent, when it first appeared, and its possible connection with pregnancy and childbirth, menopause, or gynecological surgery. The second part of the questionnaire consisted of questions relating to urge incontinence, frequency, nocturia, and symptoms of urinary tract infections. The third questionnaire was concerned with the neurological bladder. Of the 944 women questioned, 570 responded. Of these replies, 58 could not be interpreted. Of the remaining 512 replies, some were incomplete but the information lacking was secured through direct contact with the women.

Results

Three hundred twenty-one of 512 women reported urinary incontinence (Table I). This represents 7 % of the patients examined under the health control program during the period in question.

Genuine stress incontinence. Only 42 patients of 512, representing 8.2 % of all women with urinary disturbances, indicated stress incontinence without other symptoms. Twenty-three women reported stress incontinence of Grade I according to the Ingelman-Sundberg scale, 14 of Grade II, and 5 of Grade III. Of the 42 women, 11 suffered daily trouble. Eight stated that urinary incontinence restricted their social activities or their daily contacts with other people.

Urge incontinence. Thirty-four of 512 women (6.6 % of the entire material) suffered from urge incontinence alone, without other symptoms. Thirteen women reported having difficulty daily; 8 stated that the condition affected their social lives.

Mixed incontinence (symptoms of both stress and urge incontinence). The number of women with simultaneous occurrence of both stress and urge incontinence was 88. This is 17.2 % of all women who reported urinary disturbance and 27.4 % of all incontinent women. Of the 88 women, 52 suffered distress daily. Twenty-seven stated that incontinence restricted their social activities or their daily contacts with other people.

Stress incontinence combined with urgency or frequency. One hundred fifty-seven women reported difficulty in the form of stress incontinence combined with such symptoms as sensory urge or urgency and frequency (Table I). This group represents 48.9 % of the women with urinary incontinence, or 30.7 % of the entire material.

Infections of the urinary tract. Two hundred women (39.1 % of the entire material), bore symptoms or had received treatment for urinary tract infections during the preceding 2-year period. In the genuine stress incontinent group, 13 had been treated for urinary tract infections, and in the urge incontinent group, 9 had received such treatment. In the mixed incontinence group, 76 had had urinary tract infections during the preceding 2 years. Forty-five women (8.8 % of the entire material), reported recurring infection as their only disorder of the urinary tract.

Comments

Nine hundred forty-four of 4400 women examined reported that they suffered from disorders of the urinary tract. This comprises 21 % of the total examined and demonstrates quite clearly that urological disorders in women constitute a major problem. The case history is considered to be one of the most important methods in

Table I. Summary of patients studied

	Urinary disorders			Urinary tract infections		
	No.	Per cent of entire material	Per cent of incontinent patients	No.	Per cent of entire material	
Stress incontinence group						
Genuine stress incontinent	42	8.2	13.1	13	2.5	
Mixed incontinent:						
Stress + urge incontinent	88	17.2	27.4	31	6.1	
Stress + urge symptoms	157	30.7	48.9	45	8.8	
Total	287	56.1	89.4	89	17.4	
Urge incontinence group						
Urge incontinent	34	6.6	10.6	9	1.8	
Urge symptoms	137	26.8		57	11.1	
Total	171	(33.4)		(66)	(12.9)	
Urinary tract infections	45	8.8		45	8.8	
Neurological disorders	9	1.7				
Total material	512	100.0		200	39.1	

examining for urinary incontinence. Of the questions contained in the questionnaire, which were chosen with great care, one would expect to secure a greater amount of pertinent information than the routine case history notations. Despite this, it seems difficult to make more exact diagnoses of urinary tract ailments on the basis of the information contained in a questionnaire. Thus, only 42 of the persons interviewed could be classified as suffering from genuine stress incontinence. This comprises 0.9 % of 4400 women, or, if one adjusts for a response percentage of 60, 1.6 % of 2640 women. This is a considerably lower figure than those arrived at by earlier investigators (Nemir, Middleton 1954, Francis 1960, Beck 1965, Wohlin 1969). The difference lies most likely in the methods employed, as well as the different groups of women inquired. The latter investigators studied more or less selected groups of patients. Nemir, for example, studied college girls who, it might be supposed, responded with an affirmative reply in regard to stress incontinence even though this may not have constituted a medical problem for them.

The figures in the literature regarding the onset of stress incontinence in early years of life, prior to pregnancy, vary between 5 and 16.2 % (Wohlin, Nemir). Among our patients, stress incontinence began in the early years in 20 cases. This is equivalent to 7 % of all stress incontinent patients (287 women), and agrees with our questionnaire study among pregnant women (paper III). In 91 stress incontinent patients the disorder first appeared in connection with pregnancy or delivery. We did not find a connection between complicated labor and delivery and the occurrence of stress incontinence.

Two hundred patients, i.e., 39.1 % of all women who responded to the questionnaire (4.5 % of the entire material comprising 4400 women), had received treatment for urinary tract infection during the preceding 2 years. The individual reply does not indicate, however, whether the infection was verified by means of bacteriological culture, or if the woman's case history or urinary disturbance simply prompted a prescription for urinary tract antibiotics. It is likely that the latter alternative applies in most cases. Of the 200 women who had been treated for urinary tract infections, 76 could be classified as belonging to the mixed-incontinence group, comprising 31 % of the total number of women in the group. Sixty-six may be classified as belonging to the urge incontinence group, comprising 38.5 % of the total number of women in the group.

Earlier investigations carried out by Kunin and McCormack in 1968 indicated a 4.5 % incidence of urinary tract infection in a group of women between the ages of 15 and 54 years, and a 6.6 % incidence in a group of women between the ages of 55 and 65 years. In 1969, Sussman found a 3.5 % incidence of urinary tract infection in women between the ages of 20 and 64 years. He pointed out that urinary tract infections do not vary with age. Colleen 1979 showed

that 4 % of the fertile female population and 10 % of women beyond fertile ages suffer from urinary tract infections. Atrophy arising from a lack of estrogen during the menopause may increase the sensitivity of the mucous membranes to infection as well as to mechanical irritation and bring about an increase in the number of urinary tract infections and urgency frequency symptoms in the menopause. In our material, 33.5 % of urinary tract infections were found in patients between 20 and 47 years of age and 66.5 % in patients between the ages of 48 and 70.

Urinary incontinence in women may be due to an unstable bladder condition (Bates 1971). Different reports on the frequency of this condition among women who complain of urinary difficulty show different results, varying between 6 and 66 % (Hodgkinson 1963, Arnold 1973, Bates 1973, Beck 1976, Aldridge 1978, and Weprin 1980). There is no possibility whatsoever of diagnosing an unstable bladder solely on the basis of the case history. In order to establish definitely whether or not the condition exists, additional objective examination, i.e. cystometry, are required (Paper II).

The results of the current questionnaire survey thus show that urinary disturbances and urinary incontinence are very common symptoms in an ordinary female population. A comprehensive case history can, however, only serve as a guide in the selection of examination methods in carrying on an objective evaluation of the patient's complaint.

II

SIMULTANEOUS URETHROCYSTOMETRY AS A ROUTINE METHOD FOR OBJECTIVE EVALUATION OF FEMALE URINARY INCONTINENCE

Carefully prepared case history studies of stress incontinent women are also found to include a large number of "mixed" incontinent subjects; that is, cases where the patients display symptoms of both stress and urge incontinence. This is evident from the results of paper I and has also been substantiated by other investigators. We were therefore interested in ascertaining whether a urodynamic investigation would give us a more complete picture of the patients' urinary incontinence conditions than that obtained through case history and examination in the outpatients department. We were particularly interested in determining whether or not the stress and urge components could be separated, since this would be of the utmost importance with respect to the treatment of urinary incontinence.

Material and methods

Between April 1977 and April 1979, 401 patients with urinary incontinence were referred to the Women's Clinics at Lund and Malmö. The majority of the patients (70 %), came from the area of their own clinic while 30 % were referred to the clinics from other administrative districts. At the outpatients clinics patients were examined first by qualified specialists in gynecology or by gynecologists undergoing specialist training at their own clinics. An evaluation of the patients' incontinence difficulty was made after which they were sent on to the clinics' urodynamic laboratories where they were examined by means of simultaneous urethrocystometry, including urethral pressure profile measurement. The urodynamic investigations were carried out in both the supine and standing positions with increasing bladder volumes. At the outpatients' clinics, incontinence was diagnosed by observing leakage of urine from the urethra at a bladder content of 200 ml in supine or standing position and with repeated cough provocation. Bonney's test was performed as well. Incontinence was diagnosed at the urodynamic laboratory in the same manner but also by noting that the urethral closure pressure as shown by the pressure curve declined to zero or below zero in connection with leakage of urine.

Results

A review of clinical diagnoses of patients disclosed that 179 of 401, or 44.6 %, had been diagnosed as cases of stress incontinence. Simultaneous urethrocystometry revealed that 35 of these, or 19.5 %, had normal urethrocystometry. Neither did these patients show any signs of leakage, either in the supine position or standing. They were, in other words, objectively continent. In 137 of 179 patients, the clinical diagnosis of genuine stress incontinence could be verified objectively by means of urethrocystometry; that is, the patients leaked urine at the same time that a negative closure pressure was recorded under stress provocation during urethrocystometry, without evidence of any abnormal detrusor activity. Two of the 179 patients had signs of urge incontinence, while five showed signs of mixed incontinence, i.e., symptoms of both stress and urge incontinence.

Twenty-three of 401 patients referred to the clinics (5.7 %), had been clinically diagnosed as urge incontinence cases. In the urodynamic examination, one patient in this group was found to have genuine stress incontinence, while 17 had unmistakable urge incontinence. Four patients showed symptoms of frequency; that is, a strong urge to micturate, without objective evidence of incontinence, while one patient showed symptoms of mixed incontinence. Two of these patients had signs of unstable urethra.

The largest number of patients consisted of those diagnosed by the

out-patients department as mixed incontinence. No less than 199 of 401 patients (49.6 %), were in this category. After examination by simultaneous urethrocystometry, the following groups could be distinguished:

29 patients (14 %), were normal cases, i.e., with normal urethrocystometry and urethral pressure profile, and no signs of incontinence,

76 patients (38.1 %), had genuine stress incontinence,

29 patients (14.5 %), had urge incontinence,

35 patients (17.5 %), showed signs of both stress and urge incontinence,

6 patients (3 %), had neurogenic bladder disturbances,

16 patients (8 %), were diagnosed as suffering from "frequency".

Comments

A systematic objective recording of patients' complaints in investigations dealing with urinary incontinence has been very limited, presumably because of technical problems. During the 1950's and 1960's, micturition urethrocystography was the principal method employed in diagnostics of stress incontinence. Several authors, e.g. Drutz and Schapiro (1978), showed that a large number of continent women had micturition urethrocystography which was considered typical for stress incontinence. It is not surprising therefore that the value of micturition urethrocystography as an objective method for diagnosis of urinary incontinence has been called into question.

Simultaneous urethrocystometry in the investigation of urinary incontinence requires less elaborate equipment and fewer personnel than many other sophisticated methods which combine X-ray examination with, for example, electromyography and intraluminal pressure measurement (Stanton 1978). Accordingly, simultaneous urethrocystometry can also be used to advantage in routine screening examinations of many patients referred to the hospital with diagnoses of urinary incontinence. An important element in the investigation would then be to establish objectively which component, stress or urge, that is predominant in the various "mixed incontinent" patients and would require treatment first. As indicated in our material, it was possible to reduce the percentage of mixed incontinent patients from 49.6 % to 10.2 % after urethrocystometry. This reduction is most valuable from the point of view of proper future therapy.

One aim of the present investigation, though ambitious, was to

carry out the objective investigation in a manner "consistent with normal functions". The bladder was filled, for example, with a physiological saline solution at a maximum rate of 50 ml per minute. A more rapid rate of infusion or the employment of carbon dioxide cystometry might induce measurement artifacts as a forceful filling of the bladder increases the incidence of bladder instability. It is quite possible that a greater frequency of urge and stress incontinence would have been noted if we had increased the rate of infusion or had induced more violent coughing. Whether the values then obtained for detrusor instability and stress incontinence had been representative, however, is doubtful.

Unstable urethra, that is, momentary variations in urethra pressure exceeding an amplitude of 15 cm H₂O, with or without observable detrusor activity (Fig. 5), was observed quite often in patients with urge incontinence symptoms. It is interesting to note that in most of these patients the bladder pressure was entirely stable and the patients indicated urgency subjectively when the variations were observed in the urethral pressure. A closer evaluation of the significance of this finding is currently under way (Iosif et al. 1981).

Sixty-three patients (15.7 % of the entire material), proved to be continent, with normal urethral pressure profiles and urethrocystometries. It is likely that many of these patients had mild temporary stress incontinence at the time of their first visits to the out-patients department. The result, that is, the patients who were entirely continent at the time of their second visit, illustrates the importance of not referring these patients immediately to surgery but rather to await developments or go on with a urodynamic investigation and thereby possibly avoid "unnecessary" operations.

III

INCONTINENCE DURING PREGNANCY AND IN PUERPERIUM

Among gynecologists and urologists it has been speculated as to whether pregnancy and menopause play an important part in the onset of stress incontinence. As has been shown in paper I there is some basis for such a speculation. The investigations made by Francis and Beck et al., in the 1960's contain diverging figures in regard to the frequency and incidence of stress incontinence during pregnancy and the puerperium. To elucidate the significance of pregnancy, childbirth, and the puerperium in the etiology of stress incontinence, we carried out a retrospective investigation into the matter at the Women' Clinic in Lund.

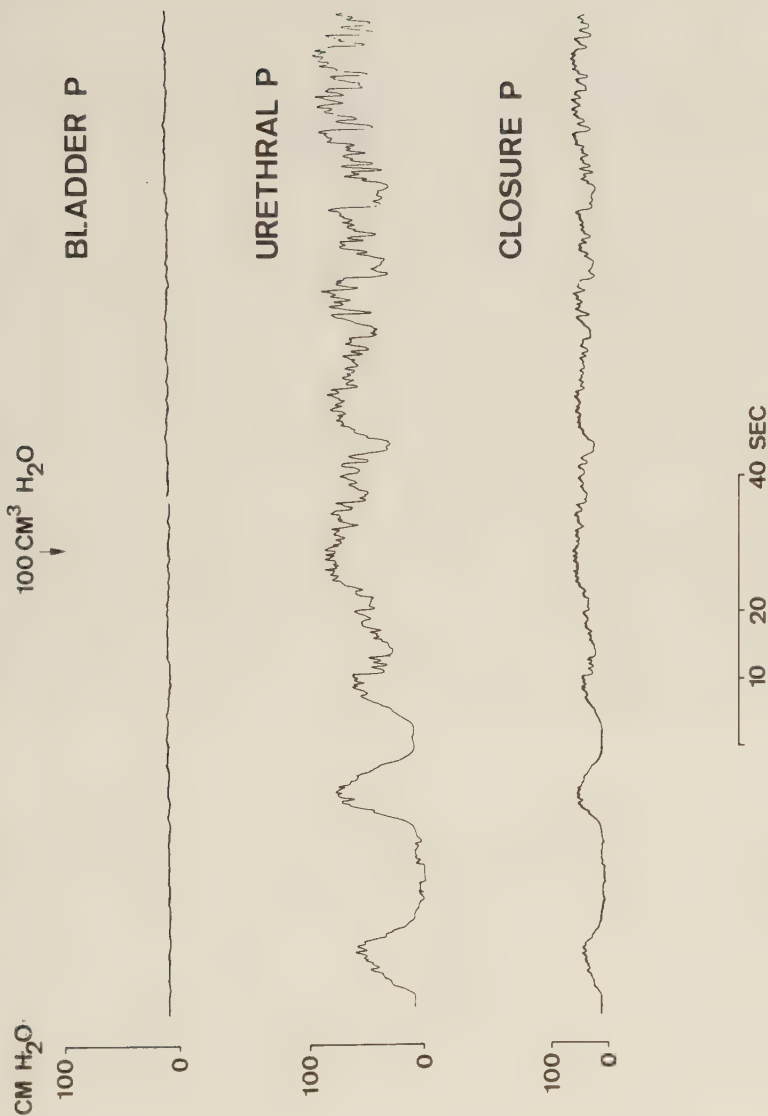


Fig. 5. Pressure tracing from one of the women with urge incontinence and unstable urethra (momentary variations in urethral pressure exceeding an amplitude of 15 cm water).

Material and methods

In a special series of instruction, the personnel in the maternity wards were informed about the problem complex surrounding urinary incontinence. The purpose was to make them attentive to the occurrence of stress incontinence difficulty among patients in the puerperium.

All maternity patients who were delivered during a 7-month period and who were confined in the maternity ward were provided with a questionnaire containing 21 questions dealing with urinary incontinence difficulty (See paper III). Of 1500 such patients, 1411 responded by filling in the questionnaire. The patients who suffered from urinary incontinence were examined by the clinic's urology specialist. Six to 12 months after childbirth a more expanded questionnaire was sent by mail to the patients who had stated in the first questionnaire that they were troubled by urinary incontinence difficulty (paper III). The objects of this second questionnaire were to screen out the patients with temporary incontinence arising in connection with pregnancy and childbirth, and to determine which factor, pregnancy or delivery, had precipitated the patient's difficulty. The extent of response to this second questionnaire was 95 %. A third questionnaire was sent out 6 months after delivery to 300 women chosen at random who had stated in reply to the first questionnaire that they had not experienced any incontinence difficulty in connection with pregnancy or childbirth. The purpose of this third questionnaire was to determine the extent to which stress incontinence appears after a period of weeks or months after delivery. In order to gain some information about the significance of genetic factors in stress incontinence, an inquiry as to whether the patients' mothers had been troubled by stress incontinence was included in all three questionnaires.

Results

Of the 1500 women who were asked to fill in the first questionnaire, 1411 (94 %) responded. The parity distribution of this material was as follows:

Para- I	541	(38.3 %)
Para- II	611	(43.3 %)
Para- III	205	(14.5 %)
Para- IV	42	(3.0 %)
Para- V	7)	
Para- VI	4)	(0.9 %)
Para- IX	1)	

1411

Three hundred twenty-one patients (22.7 %) reported stress incontinence difficulty in the first questionnaire. The more extensive second questionnaire was answered by 306 (95 %) of the 321 stress

incontinent patients.

The onset of stress incontinence in relation to pregnancy may be seen in Table II. In 26 patients (8.5 %) of the incontinent women who replied to the second questionnaire), stress incontinence had begun prior to pregnancy, while 222 women (72.5 %), stated that their distress began during pregnancy. A smaller number, 58 (19.0 %), placed the onset of their stress incontinence difficulty after childbirth. Among these women, incontinence ceased in nearly half of the cases (25 patients) a few weeks after delivery, while 33 patients remained incontinent 6-12 months after delivery.

Table II. Onset of stress incontinence correlated to pregnancy and parturition in 306 patients

Before Pregnancy	26	8.5 %
During Pregnancy	222	72.5
Manifest	69	22.5 %
Temporary	153	50.0
At Delivery	58	19.0
Manifest	33	11.0
Temporary	25	8.0
	306	100.0 %

In cases where stress incontinence began during pregnancy or soon after delivery (280 patients), case records were examined with respect to duration of labor, frequency of instrumental delivery and weight of the infants.

Of 222 patients whose stress incontinence began during pregnancy, 135 occurred during the first pregnancy. The difference in frequency between Par-I and Para-II is statistically significant ($p \leq 0.05$). Altogether, 153 of 222 patients had incontinence of "mild physiological type". This type of stress incontinence began during the second part of pregnancy and ceased approximately 3 months after delivery in practically all cases.

The difference in the frequency of this "physiological stress incontinence" between the first and subsequent deliveries was not

statistically significant.

Of 222 patients who experienced the onset of stress incontinence during pregnancy, 69 had permanent stress incontinence. Most of these patients stated that onset occurred early in the first pregnancy. The difference in frequency between Para-I and Para-II here is statistically significant ($p < 0.05$).

Of the 300 patients without urinary incontinence who were interviewed in the third questionnaire, 264 (88 %) responded. Sixteen of these (6 %) described "mild stress incontinence symptoms".

Comments

The purpose of this triple questionnaire directed to the same group of women delivered at the clinic over a 7-month period was to determine the frequency of stress incontinence and, if possible, to establish the degree of the disorder and thereby eliminate the temporary, milder form of stress incontinence. Francis reported in 1960 that 65 % of patients with stress incontinence indicated onset of the symptom during pregnancy. He found no connection between stress incontinence and the puerperium, while Beck 1965, on the other hand, stated that 14 % of all stress incontinent women indicated onset of their symptom during puerperium. Our figures are considerably lower, since only 22.7 % of the patients stated that they had symptoms of stress incontinence during pregnancy. Eleven percent of these were stress incontinent cases of a mild nature which first appeared during late pregnancy but which disappeared completely within 3 months after delivery. Only 2.3 % of the patients maintained that permanent stress incontinence appeared in connection with childbirth. This result would indicate that the element of childbirth must be ascribed less importance as a precipitating factor in stress incontinence, at least in Sweden. This might be due to the fact that with the high standard of care for maternity patients during childbirth, the traumatic experience associated with traumatic delivery is felt less frequently. The view that childbirth is of minor importance in relation to the occurrence of stress incontinence is also supported by the results of a recent investigation on patients who underwent elective Caesarean sections (Iosif et al. unpublished). In that study no difference in the percentage of permanent stress incontinence was found between women delivered by an elective Caesarean section and those delivered vaginally.

URODYNAMIC STUDIES IN PUERPERIUM

Pregnancy and childbirth are considered to predispose women to various types of difficulty in the lower urinary tract such as urge and stress incontinence as well as nocturia, urgency and frequency (Stanton 1980). Previously published investigations dealing with the lower urinary tract during pregnancy and delivery have primarily been carried out with the aid of X-ray techniques (Malpas 1949, Jeffcoate 1952, Francis 1960) whereas no systematic investigations dealing with pressure conditions in the bladder and urethra in newly-delivered women seem to be available. The purpose of this study was to investigate urethral and bladder pressure by means of electronic simultaneous urethrocystometry, in a group of newly-delivered women who developed stress incontinence during pregnancy or soon after delivery.

Material and methods

Sixty-two newly-delivered patients took part in the investigation. They were selected at random among a number who, in response to a questionnaire survey dealing with urinary incontinence, had stated that they had experienced leakage of urine during pregnancy or in the puerperium (paper III). Two of the patients had been delivered by Caesarean section. Sixty had been delivered vaginally, without complication. As to parity, 33 % were Para-I, 35 % were Para-II, 25 % were Para-III, and 4 % were Para-IV. The average age of the patients was 31.5 years, ranging from 18 to 44 years. The average weight of the children at birth was 3100 grams (range: 1300 to 4630 g). All patients were examined 7 to 14 days after delivery by means of a technique described earlier for simultaneous urethrocystometry including urethral pressure profile measurement (Amussen, Ulmsten 1976). The patients were examined in both supine and standing positions. Student's t-test was used in calculating statistical differences.

Results

After examination, two groups of patients could be distinguished:

- Group I: Patients with subjective leakage during pregnancy only in connection with vigorous exertion as, for example, heavy coughing or vomiting. No difficulty after parturition.
- Group II: Subjective persistent urinary incontinence with onset during pregnancy. Continued difficulty after delivery.

There were 35 patients in the first group; 27 in the second. Table III shows the results of the pressure measurements for both groups. As the Table shows, the maximum urethral pressure in supine posi-

Table III. Mean values, standard deviation, and statistical significance in patients with stress symptoms during pregnancy only and in patients incontinent during pregnancy and in puerperium. Urethral profile and simultaneous urethrocytometry 7 to 14 days after delivery

Variable	Group	Supine position		Standing position	
		mean $\pm$ SD	significance	mean $\pm$ SD	significance
Absolute length of urethra, mm	I	33.37 $\pm$ 3.753	0.01 < p $\leq$ 0.05 (t = 2.10)	37.20 $\pm$ 6.680	NS (t = 0.47)
	II	31.14 $\pm$ 4.400		36.26 $\pm$ 4.890	
Functional length of urethra, mm	I	27.04 $\pm$ 3.818	p $\leq$ 0.001 (t = 3.75)	29.60 $\pm$ 4.300	NS (t = 1.68)
	II	23.60 $\pm$ 3.389		26.35 $\pm$ 4.444	
Maximum urethral pressure, cm H ₂ O	I	81.80 $\pm$ 9.191	p $\leq$ 0.001 (t = 11.78)	99.96 $\pm$ 10.362	p < 0.001 (t = 6.72)
	II	48.81 $\pm$ 12.105		67.76 $\pm$ 13.731	
Bladder pressure, cm H ₂ O	I	10.02 $\pm$ 2.449	NS (t = 0.75)	29.24 $\pm$ 4.590	NS (t = 0.54)
	II	10.53 $\pm$ 2.787		28.32 $\pm$ 4.681	
Closure pressure, cm H ₂ O	I	71.73 $\pm$ 9.509	p $\leq$ 0.001 (t = 12.04)	70.72 $\pm$ 8.720	p < 0.001 (t = 4.46)
	II	38.27 $\pm$ 11.774		38.94 $\pm$ 12.328	
Maximum pressure point of urethra, mm	I	15.56 $\pm$ 2.242	0.01 < p $\leq$ 0.05 (t = 5.65)	17.40 $\pm$ 4.427	p < 0.001 (t = 3.70)
	II	12.46 $\pm$ 2.063		13.56 $\pm$ 1.948	

tion was 82 cm H₂O in Group I and 48 cm H₂O in Group II ($p \leq 0.001$). Bladder pressures were nearly identical in the two groups. Accordingly, the closure pressure was substantially lower in Group II (38.3 cm H₂O), than in Group I (71.7 cm H₂O); $p \leq 0.001$.

In the standing position the maximum urethral pressure increased in both groups (Group I 100.0 cm H₂O; Group II 67.8 cm H₂O), while the bladder pressure was unchanged (18 cm H₂O). In examinations involving the cough profile, the urethral closure pressure in Group I remained positive at all times during moderate to vigorous coughing and no objective leakage was observed. In measurement of the cough profile in Group II a closure pressure at or below zero was consistently observed. Leakage in these patients was apparent. Some showed only a dripping leakage at coughing in supine position but leaked quite considerably when coughing in standing position. In addition Bonney's test was positive in all of the patients in Group II. As shown in Table III the functional length of the urethra was 27 cm in Group I in supine position and 29.6 mm in standing position. The corresponding values for Group II were 23.6 in supine and 26.3 in standing. This difference is statistically significant ($p \leq 0.001$).

Comments

The noticeable differences between Groups I and II with regard to the urethral pressure in both the supine and standing positions (Table III) confirm earlier findings to the effect that patients with stress incontinence have a lower urethral pressure than healthy women (Beck 1964, Enhörning 1961, Henriksson 1977, Low 1972, Toews 1967). The supposition that Group I consisted of women with mild "physiological" stress incontinence is also supported by the fact that the values for the functional length of the urethra coincide with reports on continent women published earlier (Henriksson 1977, Iosif 1980, Lapidus 1960). The women in Group I had a functional urethral length of 27.0 mm, while Henriksson and his associates, for example, found a value of 25.0 mm in continent women, Group II had a functional urethral length of 23.6 mm, while stress incontinent women in the article referred to above (Henriksson et al. 1977) had a functional urethral length of 21.4 mm. Thus, in this latter case also, there was a close correlation between the findings among women who showed stress incontinence post partum and nonpregnant patients with permanent stress incontinence.

The values for urethral closure pressure obtained above agree with those reported in previous investigations (Henriksson 1977). Group I had a closure pressure of 72 cm H₂O while continent non-pregnant women in earlier studies had a closure pressure of 74 cm H₂O. This probably indicates that Group I included women with very mild stress incontinence prevailing temporarily during pregnancy since urethrocystometry in puerperium recorded a positive urethral closure pressure during cough provocations, and no urine leakage was

observed. The mild stress incontinence which is manifest only during pregnancy may be of hormonal origin and reversible. Permanent stress incontinence is likely the result of irreversible changes in the urethra and its suspension ligaments during pregnancy.

V

URODYNAMIC STUDIES OF CONTINENT WOMEN IN PREGNANCY AND IN PUERPERIUM

The physiology of the bladder during pregnancy was studied as early as 1938 by Muellner. In 1975, Clow investigated the effect of the position of the body upon the functions of the bladder and the urethra during pregnancy. He found an increased bladder pressure during pregnancy as well as an increase in the length of the urethra in standing position.

No systemic objective recordings of the urethral pressure profile during pregnancy have previously been made. It was one of the aims in this investigation to study any changes which may occur in the vital continence parameters during the course of normal pregnancy and in the puerperium.

Material and methods

Fourteen women participated in the investigation (11 pregnant for the first time; each of the others with a case history of one earlier abortion). All patients were examined according to techniques described previously for simultaneous urethrocystometry, including measurement of the pressure profile of the urethra (Asmussen, Ulmsten 1976). After each examination continence ability was tested in a standing position with repeated coughing. The first recording was made during the 12th to 16th weeks. The second recording took place during the 38th week, and the third recording was made 5 to 7 days following delivery. All of the patients were delivered vaginally. The average delivery took place at 40.5 weeks, with a range of 39 to 42 weeks. Thirteen of the infants delivered had a vertex presentation; one was delivered from an open cranial passage position. The average weight of the infants at birth was 3700 grams, ranging from 3130 to 4060 grams. All of the patients were of normal weight before pregnancy (average height: 1.68 m; average weight: 58 kg). Increases in weight during pregnancy averaged 12.3 kg.

Results

Statistically significant differences in the various continence parameters were observed between different stages of pregnancy.

The absolute length of the urethra increased from 36 mm at the beginning of pregnancy to 43 mm in the 38th week (statistically significant, $0.001 < p \leq 0.01$), decreasing thereafter one week after delivery to 32 mm. These changes are statistically significant ($p \leq 0.001$ and $0.001 < p \leq 0.05$, respectively). As can be seen in Table IV, a marked increase in the maximum urethral pressure occurred at the end of the pregnancy (from 70 cm H₂O to 93 cm H₂O) $p \leq 0.001$. After delivery the urethral pressure declined to nearly the same value as at the beginning of pregnancy, 69 cm H₂O. Bladder pressure increased from 9 cm H₂O to 20 cm H₂O toward the end of pregnancy ($p \leq 0.001$) and returned to its initial value, 9 cm H₂O, after delivery. As a result of the changes in the pressures of the urethra and the bladder, the urethral closure pressure changed. At the first recording during the 12th to 16th weeks, the closure pressure was 61 cm H₂O, after which it increased to 73 cm H₂O at the second recording, returning subsequently at the third recording to almost the same value as at the beginning of pregnancy (60 cm H₂O).

Comments

The enlargement of the uterus during pregnancy places an added burden upon the surrounding organs in the pelvis minor, particularly the bladder. A doubling of bladder pressure from 9 cm H₂O at the first recording to 20 cm H₂O in weeks 37-38 results in a reduction of bladder capacity and increased demands upon the closure ability of the urethra. The changes in the urethral parameters noted here must be regarded as positive in consideration of the added demands for maintenance of continence. The importance of the length of the urethra in maintaining continence was first pointed out by Lapedes in 1960. He considered that a long urethra contributes to continence. To compensate for the increased bladder pressure, we found that the absolute and functional lengths of the urethra increased by 7.5 and 5 mm, respectively, from weeks 12 to 16 to the 38th week. We found also that the maximum intraluminal pressure of the urethra increased by 23 cm H₂O from weeks 12 to 16 to the 38th week.

The overall effect of these changes in the urethral and bladder pressures was that the closure pressure of the urethra increased by 12 cm H₂O on an average, from weeks 12 to 16 to the 38th week, i.e., an overcompensation of continence ability occurred among our patients and closure pressure remained positive throughout the entire pregnancy, even under strong cough provocation.

Table IV. Average values for measurements made 12 to 16 weeks prior to delivery, during the thirty-eighth week, and 5 to 7 days after delivery, together with an indication of the statistical significance between the first measurement and the second and third measurements, respectively*

Variable	12 to 16 weeks preceding childbirth	Thirty-eighth week	5 to 7 days after childbirth
Absolute length of urethra, mm	36.3 $\pm$ 5.13	43.0 $\pm$ 6.34 $p \leq 0.001$	32.0 $\pm$ 3.61 $0.001 < p \leq 0.01$
Functional length of urethra, mm	30.3 $\pm$ 4.63	35.1 $\pm$ 5.12 $p \leq 0.001$	27.6 $\pm$ 3.69 $0.01 < p \leq 0.05$
Maximum urethral pressure, cm H ₂ O	70.0 $\pm$ 14.94	93.0 $\pm$ 17.29 $p \leq 0.001$	69.0 $\pm$ 14.29 NS
Bladder pressure, cm H ₂ O	9.0 $\pm$ 2.94	20.0 $\pm$ 3.03 $p \leq 0.0001$	9.0 $\pm$ 2.41 NS
Closure pressure, cm H ₂ O	61.0 $\pm$ 13.59	73.0 $\pm$ 17.51 $0.001 < p \leq 0.01$	60.0 $\pm$ 14.41 NS

NS = not significant

* Statistical significance according to Student's t test for paired observations

COMPARATIVE URODYNAMIC STUDIES OF CONTINENT AND STRESS INCONTINENT WOMEN DURING PREGNANCY AND IN PUERPERIUM

Against the background of the findings presented in paper V, it was of interest to compare continence parameters among stress incontinent women during pregnancy, at the beginning and at the end, and thereafter in the puerperium.

Material and methods

Twelve women participated in the study. Of these, 7 were pregnant for the first time, 4 for the second time, and 1 for the third time. They were referred for specialist examination by the prenatal clinics after having reported incontinence difficulty in connection with routine prenatal checkups. All patients were delivered vaginally without complication. The average delivery took place at 40 weeks with a range from 39 to 41 weeks. The average time of labor was 8 hours (range: 4-18 hours). Eleven of the infants were delivered in a vertex presentation; one had a breech presentation. The average weight of the infants at birth was 3550 grams (range: 2520-4110 g). All patients were of normal length and weight prior to pregnancy. Weight increases during pregnancy averaged 11.8 kilograms. All patients were examined by simultaneous urethrocystometry including urethral pressure profile measurement in the same manner as that described in paper V.

Results

Pressure measurement results are shown in Tables V, VI, and VII. No significant increases took place in either the absolute or the functional length of the urethra. The bladder pressure increased significantly during pregnancy from 12 cm H₂O to 21 cm H₂O in supine position ($p \leq 0.001$). The maximum urethral pressure increased slightly during pregnancy, from 54 to 62 cm H₂O in supine position and from 75 to 78 cm H₂O in standing (N.S.). The urethral closure pressure in the supine as well as in the standing positions remained unchanged during the entire pregnancy and after childbirth (Tables VI, VII).

Comments

It was discussed in paper V, that the enlargement of the uterus during pregnancy places an added burden upon the surrounding organs in the pelvis minor as seen from the increased bladder pressure. In order to compensate this increased bladder pressure, a positive physiological increase of both the urethral pressure and the urethral length takes place during pregnancy (Paper V). Previous studies have provided evidence of low urethral pressure in non-pregnant women with stress incontinence (Lapides 1960, Enhörning 1961,

Table V. Stress incontinent pregnant - supine position.

Mean values and standard deviations at registrations 1, 2 and 3, and statistical significance between the first and second, and between the first and third recordings, respectively.

Parameters recorded	Recording 1 12th-16th week of pregnancy	Recording 2 38th week	Statistical significance	Recording 3 5-7 days after childbirth	Statistical significance
Absolute length of urethra, mm	32.0 $\pm$ 5.11	32.0 $\pm$ 5.35	NS	30.0 $\pm$ 4.26	NS
Functional length of urethra, mm	25.5 $\pm$ 3.42	24.7 $\pm$ 3.11	NS	23.2 $\pm$ 2.88	NS
Maximum urethral pressure, cm H ₂ O	54.0 $\pm$ 10.32	62.0 $\pm$ 11.93	p $\leq$ 0.001	49.0 $\pm$ 8.01	p $\leq$ 0.001
Bladder pressure, cm H ₂ O	12.0 $\pm$ 4.09	21.0 $\pm$ 4.61	p $\leq$ 0.001	8.0 $\pm$ 2.07	p $\leq$ 0.01
Closure pressure, cm H ₂ O	42.0 $\pm$ 9.76	41.0 $\pm$ 10.44	NS	41.0 $\pm$ 7.13	NS
Location of maximum pressure point of the urethra related to internal meatus	12.0 $\pm$ 1.87	12.0 $\pm$ 2.38	NS	11.0 $\pm$ 1.55	NS

NS: not significant

* statistical significance according to Student's t test for paired observations

Table VI. Comparison between healthy continent pregnant women¹⁾ and stress incontinent pregnant women - supine position

Mean values and standard deviations and statistical significance between continent and incontinent pregnant women, 3 registrations in supine position. * (Recording 1: 12th to 16th week of pregnancy; recording 2: 38th week of pregnancy; recording 3: 5-7 days after parturition.)

Parameters recorded	Recording	Continent females	Incontinent females	Statistical significance
Absolute length of urethra, mm	1	36.3 ± 5.13	32.0 ± 5.11	p ≤ 0.05
	2	43.0 ± 6.34	32.0 ± 5.35	p ≤ 0.001
	3	32.0 ± 3.61	30.0 ± 4.26	NS
Functional length of urethra, mm	1	30.3 ± 4.63	25.5 ± 3.42	p ≤ 0.01
	2	35.1 ± 5.12	24.7 ± 3.11	p ≤ 0.001
	3	27.6 ± 3.69	23.2 ± 2.88	p ≤ 0.01
Maximum urethral pressure, cm H ₂ O	1	70.0 ± 14.94	54.0 ± 10.32	p ≤ 0.01
	2	93.0 ± 17.29	62.0 ± 11.93	p ≤ 0.001
	3	69.0 ± 14.29	49.0 ± 8.01	p ≤ 0.001
Bladder pressure, cm H ₂ O	1	9.0 ± 2.94	12.0 ± 4.09	NS
	2	20.0 ± 3.03	21.0 ± 4.61	NS
	3	9.0 ± 2.41	8.0 ± 2.07	NS
Closure pressure, cm H ₂ O	1	61.0 ± 13.59	42.0 ± 9.76	p ≤ 0.001
	2	73.0 ± 17.51	41.0 ± 10.44	p ≤ 0.001
	3	60.0 ± 14.41	41.0 ± 7.13	p ≤ 0.001
Location of maximum pressure point of the urethra related to internal meatus	1	14.0 ± 1.60	12.0 ± 1.87	NS
	2	16.0 ± 2.28	12.0 ± 2.38	p ≤ 0.001
	3	14.0 ± 1.46	11.0 ± 1.55	p ≤ 0.001

1) Paper V, Table I

NS: not significant

* statistical significance according to Student's

t test for paired observations

Table VII. Recording of six stress incontinent pregnant women in both supine and standing positions

Mean values and standard deviations and statistical significance between supine and standing at recordings 1, 2, and 3, for six patients examined in both supine and standing positions. *

Variable	Recording ¹⁾	Supine	Standing	Significance
Absolute length of urethra, mm	1	34.4 ± 4.63	35.4 ± 5.31	NS
	2	34.7 ± 4.67	34.7 ± 5.00	NS
	3	30.7 ± 3.26	32.0 ± 4.19	NS
Functional length of urethra, mm	1	26.7 ± 3.93	25.0 ± 5.62	NS
	2	25.7 ± 3.67	23.7 ± 5.85	NS
	3	23.0 ± 2.75	22.7 ± 3.50	NS
Maximum urethral pressure, cm H ₂ O	1	54.0 ± 10.56	75.0 ± 9.01	p ≤ 0.01
	2	61.0 ± 10.70	78.0 ± 9.43	p ≤ 0.001
	3	51.0 ± 6.35	70.0 ± 6.30	p ≤ 0.001
Bladder pressure, cm H ₂ O	1	14.0 ± 5.50	39.0 ± 2.39	p ≤ 0.001
	2	20.0 ± 4.84	40.0 ± 3.03	p ≤ 0.001
	3	9.0 ± 1.66	27.0 ± 0.00	p ≤ 0.001
Closure pressure, cm H ₂ O	1	40.0 ± 8.72	36.0 ± 9.22	p ≤ 0.05
	2	41.0 ± 8.67	38.0 ± 10.46	p ≤ 0.05
	3	42.0 ± 5.14	43.0 ± 5.08	NS
Location of maximum pressure point of the urethra related to internal meatus	1	12.4 ± 2.33	12.0 ± 2.19	NS
	2	12.0 ± 2.82	11.0 ± 3.03	NS
	3	10.7 ± 1.63	10.4 ± 1.50	NS

1) Recording 1: 12th to 16th week of pregnancy
 Recording 2: 38th week of pregnancy
 Recording 3: 5-7 days after parturition

NS: not significant

* statistical significance according to Student's t-test for paired observations

Beck 1964, Toews 1967, Edwards 1974, Henriksson 1977). In the previous studies of continent pregnant women, we found an increase of the maximum urethral pressure by 23 cm H₂O between weeks 12 and 16 and the 38th week in the supine position (Table VI). Among the incontinent pregnant women, this increase amounted to only 8 cm H₂O (Table V). The bladder pressure increased among incontinent pregnant women from 12 cm H₂O in week 12 to 21 cm H₂O in the 38th week. As shown in Table V, the closure pressure remained unchanged during pregnancy among the stress incontinent pregnant women (42 cm H₂O in weeks 12 to 16, and 41 cm H₂O in week 38). Thus, in the incontinent pregnant women no compensating increase in urethral closure pressure took place, and changes in position from supine to standing led to a reduction of the closure ability of the urethra. These changes were statistically significant (Table VII - $p \leq 0.05$). Contradictory views in regard to the importance of the length of the urethra in maintaining continence may be found in the literature (Lapides 1960, Henriksson 1977, Edwards 1974, Toews 1967). In our studies of normal, continent pregnant women (Paper V), we noted an increase in the absolute and functional length of the urethra during pregnancy (Table VI), whereas no increase in the absolute or functional length of the urethra occurred among stress incontinent women during pregnancy (Tables V, VI, VII).

GENERAL DISCUSSION

Although modern computer technology today has greatly simplified processing of sophisticated and complicated information contained in completed questionnaires, this study has clearly shown that the value of objective tests for urinary incontinence cannot be over-emphasized. Despite the extensive nature of the questionnaire, it proved to be difficult to differentiate among the various types of urinary incontinence on the basis of the replies received. Without objective examination it is impossible to establish the degree of incontinence or to detect incontinence which arises from detrusor dysynergy. Definitive measures of treatment for urinary incontinence based solely on questionnaires of the type mentioned above must therefore be rejected. It should also be kept in mind that urinary tract infections may lurk beneath frequency or urge incontinence symptoms.

Without urodynamic examinations, a large number of these patients would have run the risk of undergoing "unnecessary" surgical or pharmacological treatment. It is therefore highly desirable that qualified case history documentation on urinary incontinent women, even if carried out by specialists in gynecology, is supported by objective examinations.

In view of the large number of patients who suffer from urinary incontinence disorders, a simple yet reliable method of differentiating between the various types of urinary incontinence is needed. Experience gained from this investigation together with that reported previously indicates that simultaneous urethrocystometry with microtransducers can be used both in clinical routine and in research work. This method in comparison with combined pressure flow measurements and X-ray examinations is quite simple. It does not emit radiation, does not require a great deal in the way of personnel, nor does it demand large well-equipped laboratories. Examinations by this method can be carried out quickly without any discomfort to the patient. A need for caution in the handling of catheter equipment since it can be damaged easily must, however, be pointed out. In comparison with CO₂ urethrocystometry the method is considerably more physiological, especially if a low rate of infusion is used.

It has long been contended by many gynecologists that the onset of stress incontinence is related to specific events in a woman's life, such as pregnancy, childbirth, menopause, or gynecological surgery. In works carried out at the end of the 1940's, Malpas pointed out the significance of mechanical injury during delivery as a precipitating factor in stress incontinence (Malpas 1949). Concerning the frequency of stress incontinence with onset during pregnancy and the puerperium, however, several investigations conducted during the 1950's and 1960's have produced divergent results (Francis 1960, Beck 1965). In the large questionnaire survey dealing with the onset of stress incontinence in connection with pregnancy (Paper III), we found that 8.5 % of stress incontinence, in 306 patients, first appeared prior to pregnancy. Fifty percent indicated mild or moderate incontinence difficulty during pregnancy. In all cases the difficulty disappeared approximately 3 months after delivery. Twenty-two percent of patients showed a high degree of stress incontinence with onset early in pregnancy, and persisting thereafter in the post partum period.

A urodynamic objective evaluation revealed that the important parameters for continence, urethral pressure and the functional length of the urethra did not differ significantly in post partum women who had experienced mild stress incontinence during pregnancy and continent nonpregnant women. We found on the other hand that in pregnant women with permanent stress incontinence the patients had low urethral pressure and a short functional length of the urethra, which is also in agreement with the findings in earlier investigations of non-pregnant stress incontinent women (Paper IV). It is more likely that the pregnancy in itself, hormonal factors and possibly predisposing hereditary traits are more significantly related to the onset of permanent stress incontinence than delivery trauma.

In contrast to X-ray examination techniques, simultaneous urethro-

cystometry permits us to study the important continence parameters during pregnancy. In healthy continent pregnant women a positive increase in both urethral pressure and length was found with advancing pregnancy (Paper V). Consequently, the increased bladder pressure resulting from the enlargement of the uterus was overcompensated, and therefore the urethral closure pressure remained positive even at the end of pregnancy. In contrast, patients experiencing onset of stress incontinence early in pregnancy showed no such compensation of urethral length and maximum pressure (Paper VI). As a result, the urethral closure pressure at rest declined with increasing gestational age and the patients became highly stress incontinent at the end of pregnancy. This lack of a compensating increase in urethral pressure and length in stress incontinent pregnant women was brought out quite clearly when the patient was examined in the supine and standing positions. Recording in standing position thus revealed a reduced closure pressure among the incontinent pregnant women compared to an unchanged or increased closure pressure in the continent pregnant women. The reason for this difference is not clear. One may speculate that there was a hereditary weakness in the muscle and connective tissues in incontinent women which was further exposed to unfavorable factors during pregnancy.

The results of the present investigation show that the delivery trauma does not seem to play any decisive role in precipitating stress incontinence (Paper III). This clearly points to the need for more detailed investigations on other possible factors emerging during pregnancy which may have important bearing on continence parameters. Hormonal and mechanical factors in this respect appear to be natural targets for future research into the pathophysiology of urinary incontinence.

CONCLUSIONS

1. A questionnaire survey carried out among 4400 women between the ages of 20 and 70 years, indicated that 21 % were troubled by disorders of the urinary tract. In the 512 women who answered a questionnaire in detail the frequency of the various types of incontinence was: 8.2 % genuine stress incontinence, 6.6 % urge incontinence, 47.9 % "mixed incontinent". The remaining 37.3 % comprised a group having urge symptoms or urinary tract infections or neurological disorders.
2. Simultaneous urethrocystometry with urethral pressure profile measurement was proved to be a practical routine method suitable for objective screening of patients with urinary incontinence difficulty. A comparison of diagnoses made from these measure-

ments with that given on clinical grounds revealed a poor correspondence between the two. Not only a considerable discrepancy was found between the type of incontinence but in fact as many as 15.7 % of the out-patients referred to as incontinent were found to be continent in urethrocystometry.

3. Two important periods that appear to increase the risk of stress incontinence are pregnancy and menopause. Of the instances of stress incontinence which first occur during pregnancy (frequency 22 %), 50 % appear to be of a temporary, mild nature, disappearing approximately 3 months after childbirth. The onset during the first pregnancy is most common ($p \leq 0.05$).
4. An analysis of various delivery parameters among incontinent pregnant women and a group of continent pregnant women chosen at random did not indicate any statistically significant differences between the two. The pregnancy in itself, hormonal factors, and possibly predisposing hereditary traits seem to be more significantly related to the onset of permanent stress incontinence than delivery trauma.
5. Urodynamic studies of women in the puerperium showed that the various parameters recorded in women with temporary stress incontinence during pregnancy were comparable to those measured in healthy continent women. In women with permanent difficulty after childbirth a short urethral length and a low pressure at rest could clearly be recorded.
6. Important physiological changes in urodynamic parameters take place during pregnancy in healthy continent women. The absolute and the functional length of the urethra increase significantly. There is also a progressive increase in the bladder pressure but this is more than compensated by the increased urethral pressure so that the urethra closure pressure in fact shows a significant elevation. These changes contribute in a positive manner to maintaining continence. In contrast, a short urethra and low urethral pressure are seen in stress incontinent pregnant women. Since there is no compensating change in the urethral length or pressure, negative closure pressure and urinary leakage during stress provocation increase as the pregnancy progresses.

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THE FREQUENCY OF DISORDERS OF THE LOWER URINARY TRACT, URINARY INCONTINENCE IN PARTICULAR, AS EVALUATED BY A QUESTIONNAIRE SURVEY IN A GYNECOLOGICAL HEALTH CONTROL POPULATION

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Abstract. Four thousand four hundred women were examined under the gynecological health control program in Malmö municipality during a period of 11 months. Nine hundred and forty-four (21 per cent) reported that they were troubled by disorders of the urinary tract. These women were given copies of a separate questionnaire, which was subsequently properly answered by 512 women. Of these, 321 (62.7 per cent) indicated urinary incontinence. From the questionnaire alone, it was difficult to characterize the different types of urinary incontinence in the patients. Thus only 42 women (8.2 per cent) seemed to suffer from genuine stress incontinence and 34 women (6.6 per cent) from genuine urge incontinence, whereas 245 (47.9 per cent) had to be characterized as "mixed incontinent". Hence, it is obvious that in several patients suffering from urinary incontinence, written or combined written and oral interviews do not produce a clear-cut diagnosis and that the etiology and treatment of incontinence in these patients may be uncertain. It is concluded that interviews with most patients suffering from urinary incontinence must be supplemented by objective recordings before a definitive diagnosis and treatment can be prescribed.

Urinary disorders in women are commonplace (2, 7). Among the most distressing of these are the various forms of incontinence which often profoundly inhibit the social functions of women.

Some investigators have estimated the incidence of urinary incontinence in all women as reaching up to 50 per cent (2, 7, 14, 17). These investigations, however, have concerned themselves with particular occupational categories (student nurses), age groups (high school girls), or hospital clientele. The difficulty encountered in these studies has always been to secure a group which is representative of the female population as a whole.

The gynecological health control program in Malmö is open to all women between the ages of 21 and 70. Ten per cent of the population avail themselves of the benefit and the examination covers

all categories of inhabitants. It may therefore be considered as being quite representative of the female population as a whole (3).

The purpose of the present investigation has been to evaluate the frequency of urinary incontinence in this segment of the population, as well as the value of the information contributed by the patients themselves to the analysis of this disorder.

MATERIAL AND METHODS

Of the 250 000 inhabitants of the municipality of Malmö, 5 000 women are examined each year under the gynecological health control program. In this connection the women fill in a form which includes the following question: Are you troubled by urinary difficulty? Of 2 000 women who were examined under the program during the period August to December 1977, 540 (27 per cent of all those examined) answered this question affirmatively. During the period January to June 1978, 2 400 women were examined. Of these, 404 (16.8 per cent of the total) reported urinary disturbances. Following the health control examination, the women who indicated that they suffered from urinary difficulties were provided with a questionnaire (Figs. 1, 2, 3). Page one of the questionnaire dealt with the matter of stress incontinence, inquiring as to its extent, when it first appeared, and its possible connection with pregnancy and childbirth, menopause, or gynecological surgery. The second part of the questionnaire consisted of questions relating to urge incontinence, frequency, nocturia, and symptoms of urinary tract infections. The third part was concerned with the neurological bladder.

Table I. Age distribution. Gynecological health control population.

Age group	20-27	28-37	38-47	48-57	58-70	Total
No. of patients	47	60	65	158	182	512
Per cent	9.2	11.7	12.7	30.9	35.5	100.0

Fig. 1. Stress incontinence.

	Yes	No
1. Do you suffer from involuntary discharge of urine?		
2. Does this happen every day?		
3. Does this occur during physical activity, or in exertion, such as:		
a) vigorous coughing or heavy lifting?		
b) walking on stairways, or rapid movement on level ground?		
4. Does it restrict your social activities or your daily contacts with others?		
5. While in a standing position, does urine escape without your exerting yourself?		
6. When you perform such activities or exertions as those mentioned above, does urine escape <i>without</i> your experiencing a strong urge to pass water?		
7. Are you obliged to wear a sanitary napkin or change underclothing several times a day?		
8. Do you cough a good deal?		
9. When did this involuntary discharge of urine during physical exertion begin?		
a) in childhood?		
b) before menopause?		
c) after menopause?		
d) during pregnancy?		
e) after childbirth?		
f) following surgery of the lower abdomen?		
10. Did the discharge of urine become worse during (1st, 2nd, 3rd, etc.) pregnancy? Immediately following the (1st, 2nd, 3rd, etc.) childbirth? Following surgery of the lower abdomen? After menopause? (Underline that which applies.)		
11. Do you suffer from prolapse difficulty?		
12. Have you been operated on for uterine prolapse?		
13. Has your uterus been surgically removed?		
14. If so, was the neck of the uterus also removed?		
15. How many confinements have you had?		
16. How many children were delivered by:		
a) vacuum extractor?		
b) forceps?		
c) cesarean section?		
17. How many children weighed more than 4 kg at birth?		
18. Did any serious rupture occur during any of the deliveries which required stitches by the doctor?		

Of the 944 women questioned, 570 responded. Of these replies, 26 could not be interpreted. Thirty-two women had no urinary difficulty at the time of the survey. Of the remaining 512 replies, some were incomplete but the information lacking was obtained by direct contact with the women. The distribution of the 512 women by age group is shown in Table 1.

RESULTS

Of 512 women, 321 (62.7 per cent) indicated urinary incontinence (Question I:1). This represents 7 per cent of all patients examined under the health control program during the period in question. Forty-two of 512, representing 8.1 per cent of all women with urinary disturbances, and 13.1 per cent of the incontinent patients, respectively, had case histories of genuine stress incontinence without other symptoms. The number of "mixed incontinent" women, i.e. those who had symptoms of both stress and urge incontinence, was 245, representing 47.9 per cent of the entire material, and 76.3 per cent of all women with

incontinence, respectively. Of these 245, 88 women (i.e. 17.2 per cent of the entire group, or 27.4 per cent of the patients with incontinence) suffered from stress incontinence combined with genuine urge incontinence. One hundred and fifty-seven women (30.7 per cent of the entire group, or 48.9 per cent of the patients with incontinence) had symptoms of urgency such as nocturia and frequency but without actual urge incontinence, in addition to an actual stress incontinence (Table II).

The genuine urge incontinent women (Table II) were 34 in number, 6.6 per cent of all patients, or 10.6 per cent of the incontinent women. One hundred and thirty-seven patients reported symptoms of urgency alone (frequency, nocturia), but denied incontinence. This is 26.8 per cent of the 512 women with urinary disturbances.

Stress incontinence. Altogether 287 of 512 women with urinary disturbances, i.e. 50 per cent, reported stress incontinence (42 with genuine stress incontinence, 88 with stress and urge incontinence, and 157

Fig. 2. Urge incontinence.

	Yes	No
1 Do you experience a burning sensation when passing water?		
2 Do you have pains in the bladder area, that is, the area above the pubic hairs?		
3 Do you commonly have a very strong urge to pass water, but are able to hold on until you reach a toilet?		
4 Do you commonly get such a very strong urge that you <i>cannot</i> hold on until you reach a toilet?		
5 Is it necessary for you to urinate more than 10 times during a 24-hour period?		
6 Do you need to urinate more than twice per night?		
7 Did any of the difficulties mentioned above begin during childhood?		
8 Did any of the difficulties mentioned above begin prior to menopause?		
9 Did any of the difficulties mentioned above begin after menopause?		
10 Do you still have menstruation?		
11 Do you suffer from intestinal catarrh?		
12 Have you received treatment for bladder catarrh during the past 2 years?		
13 Have you received treatment for inflammation of the kidney pelvis during the past 2 years?		
14 Does the sound of running water bring forth an urge to urinate?		
15 Do you often have to seek a toilet while you are out shopping?		
16 Do you suffer from severe pains during menstruation?		
17 Does your urinary difficulty become aggravated during menstruation?		

Fig. 3. Incontinence due to other causes.

	Yes	No
1 Were you a bedwetter as a child?		
2 Do you now as a grown-up wet the bed?		
3 Do you suffer constant leakage of urine?		
4 Can you cut off the flow of urine when urinating?		
5 Do you experience difficulty in emptying the bladder completely?		
6 Have you had to be drained of urine by means of a catheter because of this?		
7 Do you have to exert heavy strain in order to empty the bladder?		
8 Do you commonly feel a very strong urge to urinate before visiting the toilet?		
9 Did the urinary trouble described above first appear in connection with a serious back injury, diabetes, paralysis, or spinal operation? (Underline that which applies.)		
10 What is your approximate normal weight?		
11 What is your approximate height?		

Table II. Summary of patients studied.

	Urinary disorders			Urinary tract infections	
	No.	Per cent of entire material	Per cent of incontinent patients	No.	Per cent of entire material
Stress incontinence group					
Genuine stress incontinent	42	8.2	13.1	13	2.5
Mixed incontinent:					
Stress + urge incontinent	88	17.2	27.4	31	6.1
Stress + urge symptoms	157	30.7	48.9	45	8.8
Total	287	56.1	89.4	89	17.4
Urge incontinence group					
Urge incontinent	34	6.6	10.6	9	1.8
Urge symptoms	137	26.8		57	11.1
Total	171	(33.4)		(66)	(12.9)
Urinary tract infections	45	8.8		45	8.8
Neurological disorders	9	1.7			
Total material	512	100.0		200	39.1
Replies excluded					
Indeterminate (26)					
No disorder (32)					

Table III. First appearance of stress incontinence.

	No.	Per cent
Childhood, or early years prior to menstruation	20	7.0
During pregnancy	43	15.0
After childbirth	48	16.7
Before menopause (not specified)	49	17.1
After menopause	91	31.7
Following lower abdominal surgery	36	12.5
Total	287	100.0

with stress incontinence combined with urgency symptoms). With respect to the onset of stress incontinence, one finds that 20 women (7.0 per cent) became stress incontinent when young, i.e. prior to pregnancy. Forty-three (15.0 per cent) first began to experience their difficulties in connection with pregnancy, and 48 (16.7 per cent) after the childbirth. There was no connection between the duration of labor or its character (i.e. whether cesarian section, forceps, or normal birth), and the onset of urinary incontinence. Thirty-six women (12.5 per cent) became stress incontinent following surgery in the lower abdomen. Of these women, 10 had been operated on for prolapse and 26 had undergone hysterectomy (20 totally, 6 subtotally). Forty-nine women (17.1 per cent) acquired their symptoms prior to menopause, while 91 (31.7 per cent) first experienced stress incontinence after menopause.

Forty-two of 512 patients (8.2 per cent of the entire material) had case histories of *genuine stress incontinence* without other symptoms (Questions I:1, 3, 5, 6). Twenty-three women reported stress incontinence of Grade I according to the Ingelman-Sundberg scale (10) (Question I:3a), 14 of Grade II (Question I:3b), and 5 of Grade III (Question I:5).

Of the 42 women, 11 suffered daily trouble (Question I:2). Eight stated that urinary incontinence restricted their social activities or daily contact with other people (Question I:4).

"*Mixed incontinence*" (symptoms of both stress and urgency incontinence, or stress and urgency symptoms). The number of women with simultaneous occurrence of both stress and urge incontinence was 88. This is 17.2 per cent of all women who reported urinary disturbance and 27.4 per cent of all incontinent women.

Forty women also reported symptoms of urinary tract infections (Questions II:1, 3), and 24 had been treated for this disorder during the previous 2 years (Questions II:12, 13).

One hundred and fifty-seven women (30.7 per cent of the entire material, 48.9 per cent of all patients with incontinence) reported stress incontinence combined with urgency symptoms but without definite urge incontinence, i.e. frequency and nocturia (Table II).

Urge incontinence. One hundred and seventy-one patients (33.4 per cent of the entire material) had urgency symptoms with or without urge incontinence. However, only 34 (6.6 per cent of the entire material) suffered from *genuine urge incontinence*, without other symptoms (Question II:4). Thirteen of these women (7.6 per cent) reported having difficulty daily (Question I:2); 8 (4.7 per cent) stated that the condition had an effect upon their social lives (Question I:4). Five patients (2.9 per cent) first experienced difficulties during childhood (Question II:7). In 6 patients (3.5 per cent) the difficulty began prior to menopause (Question II:8), and in 14 cases (8.2 per cent), after menopause (Question II:9). It could not be established that childbirth or surgery had had any influence in precipitating the urgency.

One hundred and thirty-seven women reported symptoms of urgency without definite incontinence. They represent 26.8 per cent of the entire material, or 3.1 per cent of all women examined under the health control program during the period.

Infections of the urinary tract. Two hundred women (39.1 per cent of the entire material) bore symptoms or had received treatment for urinary tract infections during the preceding 2-year period (Questions II:12, 13). In the genuine stress incontinent group, 13 (2.5 per cent) had been treated for urinary tract infections, and in the genuine urge incontinent group, 9 (1.8 per cent) had received such treatment. In the mixed incontinence group, 76 (14.9 per cent) had had urinary tract infections during the preceding 2 years. Forty five women (8.8 per cent of the entire material) reported recurring infection as their only disorder of the urinary tract.

DISCUSSION

Nine hundred and forty-four of 4400 women examined reported that they suffered from disorders of the urinary tract. This comprises 21 per cent of the total examined and demonstrates quite clearly that urological disorders in women constitute a major problem.

In addition to the simple objective routine methods of examination such as urine cultures, sedimentation,

and cystoscopy, case history has played a prominent part in establishing the exact urological diagnosis. It is only in recent times that it has become possible to carry out more advanced methods of examination such as flow measurement and simultaneous pressure measurement of urethra and bladder at certain specialized clinics. Case history, however, still occupies an important position in investigations of urinary tract disorders.

The questions put forth in the present questionnaire are chosen with great care and undoubtedly provide more valuable information than the routine case history notations made in clinical work. It is therefore surprising that, despite this, it is difficult to make more exact diagnoses of urinary tract ailments on the basis of the information contained in the questionnaire. Only 42 of the persons interviewed could be classified with certainty as belonging to the genuine stress incontinent group. This comprises 0.9 per cent of 4400 women, or, if one "adjusts" for a response percentage of 60, 1.6 per cent of 2640 women. Regardless of the method of calculation, this is a much lower frequency figure than those obtained in earlier investigations (2, 7, 14, 17). The difference may lie in the questionnaire employed in the present investigation, since it is possible that our questions were more extensive and better able to segregate the purely stress incontinent patients, in comparison with questions in earlier investigations. In addition, the present material consists of women who consider themselves distressed by urinary tract problems.

In the practical evaluation of the genuine stress incontinent patients, the 8 women with daily distress may be adjudged to be clear cases for surgery. Treatment of the women suffering from moderate stress incontinence Grade I must be considered individually. In these cases one may choose among physiotherapy, pharmacological treatment, or surgery, depending upon the woman's attitude toward her disorder, but a more reliable evaluation can best be made by means of urethrocystometry under provocation (4, 13). The women with disorders of Grades II - III, according to the Ingelman-Sundberg scale (10), i.e. a total of 19 women in this investigation, can probably also be placed in this category.

As regards the onset of stress incontinence in early years, prior to pregnancy, information in the literature varies between 5 and 16.2 per cent (14, 17). In our patients stress incontinence began in childhood in 20 women, equivalent to 7 per cent of all women complaining of stress incontinence.

Earlier investigations concerning the roles of pregnancy and childbirth in the onset of incontinence are at variance. Francis (7) states that 85 per cent of pregnant women are stress incontinent. Francis & Jeffcoate contend that stress incontinence does not develop in the puerperium (8). Beck (2) in 1965 found 64.5 per cent stress incontinence during pregnancy and 14.1 per cent in the puerperium. In 91 of the women in the present investigation, i.e. 31.7 per cent, stress incontinence symptoms first appeared either during pregnancy or in the puerperium (43 during pregnancy, 48 in the puerperium). We did not find a connection between complicated labor and delivery and the occurrence of stress incontinence. This is in agreement with a recent study (12) in which a statistical analysis of parturition parameters between continent and incontinent women showed no significant difference.

Thirty-six of 287 women (12.5 per cent) experienced the onset of urinary tract disorder as occurring in connection with surgery of the lower abdomen. The fact that surgery of this kind may be detrimental to vital parameters in maintaining continence has been demonstrated earlier (9, 11, 15).

Of the 287 stress incontinent women, 91 reported that their discomfort began in connection with or following menopause. It is well known that many women become stress incontinent or that their symptoms become intensified during or after menopause. Some authors contend that this is caused by a reduced estrogen level, which leads to a deterioration of blood circulation in the mucous areas of the urethra, thereby impairing proper urethral closure (6). Moreover, intensive estrogen therapy is said to relieve the symptoms, provided that the damage is not to be found at receptor level (6, 16).

Two hundred and forty-five women in our investigation had stress incontinence in combination with other incontinence symptoms. Clinically, this means that the complaints of all of these women must be analyzed further by means of objective examination methods to determine the causes of the disorders. Objective treatment based solely upon the information derived from the questionnaire must be considered most inadvisable in these patients.

It is noteworthy that 200 women, or 39.1 per cent of all those who responded to the questionnaire, had received treatment for urinary tract infection during the preceding 2 years. Seventy-six of them could be classified as belonging to the mixed-incontinence group, comprising 31.0 per cent of the 245 women in

this group. Since it is known that the danger of relapse for urinary tract infections within one year is high (5), one may assume that a large share of the subjective problems in this group are caused primarily by infection. This assumption illustrates the difficulties involved in making an objective evaluation of patients' "subjective" replies, since the symptoms of urinary tract infection naturally coincide to a very great degree with the symptoms of urinary incontinence. It also brings out the importance of utilizing urine cultures and sedimentation tests when examining all women with urinary tract disorders.

Bates (1) has coined the expression "unstable bladder", a condition currently regarded as afflicting some 10 to 20 per cent of all women who complain of urinary tract disturbances. Most authors are of the opinion that the condition is due to partially uninhibited detrusor contractions. In the questionnaire survey, there must certainly be several women with unstable bladders in each of the stress, urge, and mixed incontinence groups. There is in any event no possibility whatsoever of diagnosing these women solely on the basis of case history. In these cases, cystometry or simultaneous urethrocystometry must be performed in order to establish definitely whether or not the condition exists (13).

In summary, this investigation has shown that an adequate diagnosis and treatment of urinary tract disorders in women can seldom be based upon case history alone. The great majority of patients' complaints require a wider factual background and special methods in order to be able to apply reliable and successful therapy. Extensive computer-based case history interviews must therefore be accorded limited value in the analysis and treatment of urinary tract disturbances in women. Analysis of this type can be of value, however, in providing information as to the frequency of urinary tract disorders among the female population, which in turn could form a basis for decisions in the health and welfare sector of the economy.

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Urethrocystometry as a Routine Method for the Objective Evaluation of Women with Urinary Incontinence

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Summary. Over a 2-year period, 401 patients with urinary incontinence were examined at the Women's Clinics in Lund and Malmö and then investigated by urethral pressure profile measurement and simultaneous urethrocystometry. After full investigation the patients could be classified as follows: 214 (53.4%) had genuine stress incontinence, 48 (12.0%) had genuine urge incontinence, 41 (10.2%) had mixed incontinence, 20 (5.0%) had urgency-frequency, 6 (1.5%) had neurogenic incontinence, 9 (2.2%) had incontinence of uncertain aetiology, and 63 (15.7%) of the patients were apparently continent with normal urethral pressure profiles and urethrocystometrograms.

Key words: Simultaneous urethrocystometry – Urethral pressure profile – Stress incontinence – Urge incontinence – Mixed incontinence

The results of treatment of urinary incontinence in women depend upon correct diagnosis. Since many patients have symptoms of both stress and urge incontinence, an objective judgement of the patient's symptoms is desirable as a basis for a decision about treatment.

At the Women's Clinics in Malmö and Lund, simultaneous urethrocystometry, including urethral pressure profile measurement, is used routinely for patients with urinary incontinence. Experience has shown that this investigation often leads to the revision of diagnoses based on the case history and routine gynecological examination. We now present a systematic comparison of clinical diagnoses and those based on the results of urethrocystometry.

Methods

Between April 1977 and April 1979, 401 patients with urinary incontinence were referred to the Women's Clinics at Lund and Malmö (Table 1). After clinical assessment the patients were

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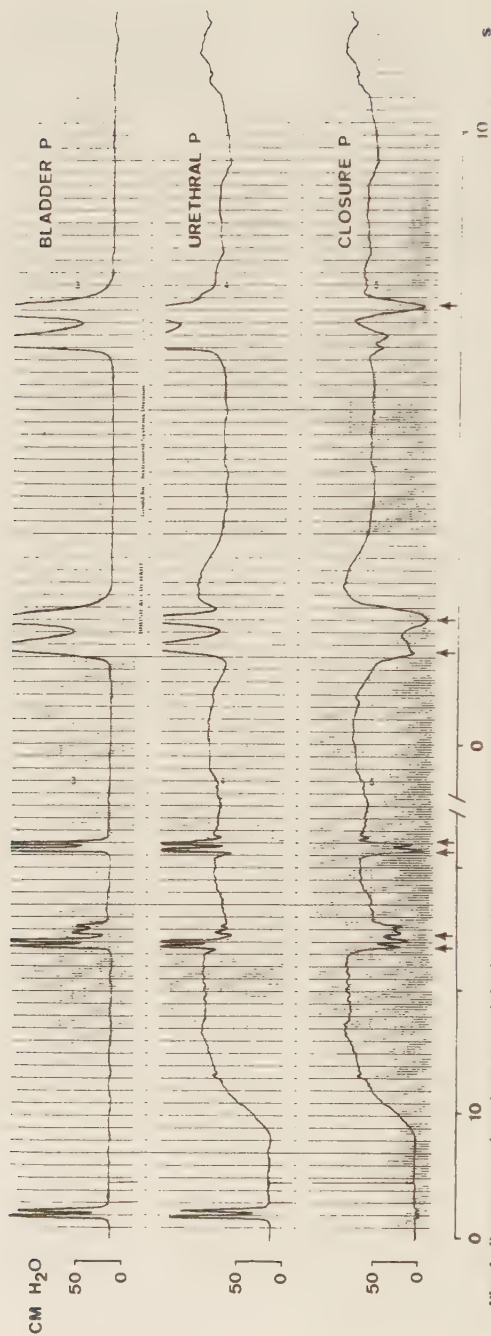


Fig. 1. Pressure tracings from one of the incontinent women. Upper trace: bladder pressure; middle trace: urethral pressure; lower trace: urethral closure pressure, i.e., urethral pressure minus bladder pressure. Note the negative closure pressure during coughing.

Table 1. Diagnosis based on results of history and clinical examination

Type of incontinence	Number of patients	%
Stress incontinence	179	44.6
Urge incontinence	23	5.7
Mixed incontinence	199	49.6
	401	100.0

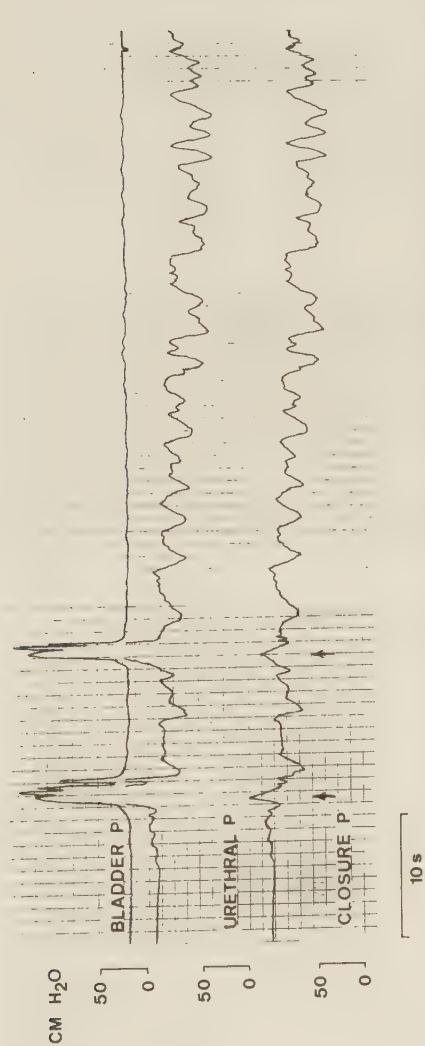


Fig. 2. Pressure tracings from one of the women with urge incontinence and an unstable urethra (momentary variations in urethral pressure exceeding an amplitude of 15 cm water). Upper trace: bladder pressure; middle trace: urethral pressure; lower trace: urethral closure pressure

investigated by simultaneous urethrocystometry and urethral pressure profile measurement [11]. The examination was usually done with the patient supine and standing and has been described in detail earlier [12]. Incontinence was diagnosed if we saw urine leak from the external urinary meatus or if the urethral closure pressure (urethral pressure minus bladder pressure), fell to 0 or below 0 with leakage of urine (Fig. 1).

For definitions of the terms continence, stress incontinence, urge incontinence, mixed incontinence, and unstable bladder, we would refer readers to ICS standards [6]. An unstable urethra was diagnosed if there were urethral pressure waves exceeding an amplitude of 15 cm water (Fig. 2).

Results

The diagnoses based on urethrocystometric examination of patients judged clinically to have stress incontinence (179 patients), urge incontinence (23 patients), and mixed incontinence (199 patients), are shown in Figs. 3–5. Table 2 shows the overall distribution of diagnoses made by urethrocystometry.

Discussion

The systematic use of objective methods for investigating urinary incontinence has been very limited and confined to radiological techniques. Jeffcoate (1952) discussed the role of an absent urethrovesical angle in stress incontinence [7], and this angle has been studied by micturating urethrocystograms (MUCG). Baily [1] in 1956 described seven different anatomical variations of the urethrovesical angle in urinary incontinence, while Greenwald in 1967 showed that 93.3% of women with incontinence and 65% of healthy, continent women had an abnormal MUCG [5] but Schapiro and Drutz [3], showed that 82% of continent women have a “defective” MUCG, suggesting that the MUCG must be of limited value for the investigation of stress incontinence.

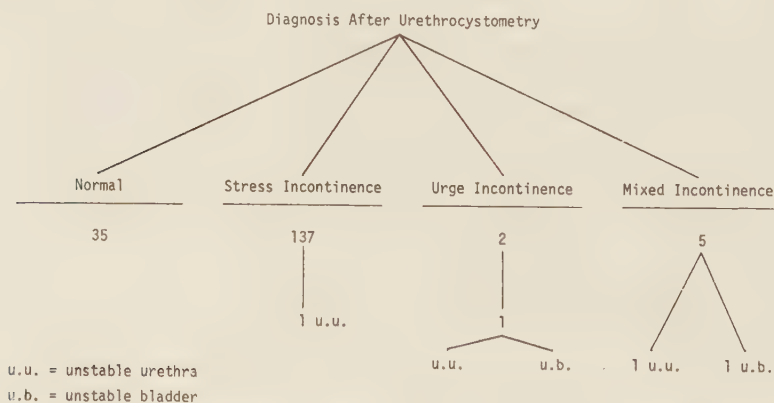
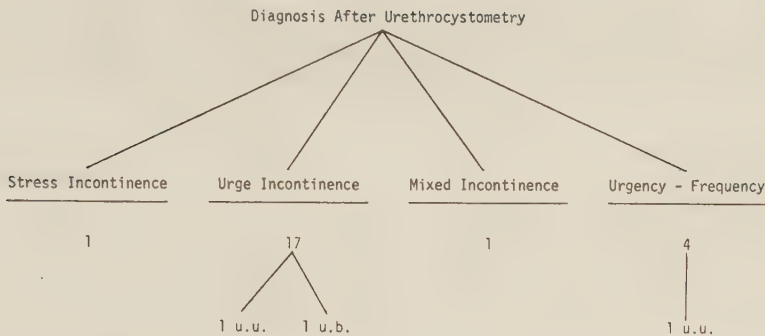
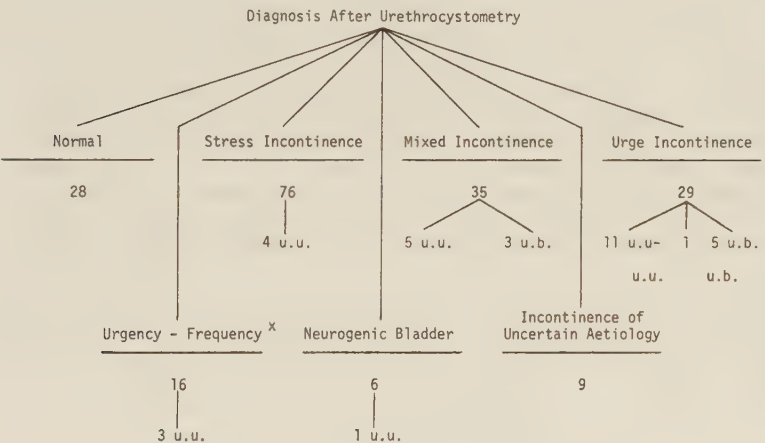


Fig. 3. Urethrocystometric findings in 179 patients thought to have stress incontinence on clinical grounds



u.u. = unstable urethra
u.b. = unstable bladder

Fig. 4. Urethrocytometric findings in 23 patients thought to have urge incontinence on clinical grounds



^xContinent but bladder capacity below 200 ml.

u.u. = unstable urethra
u.b. = unstable bladder

Fig. 5. Urethrocytometric findings in 199 patients thought to have mixed incontinence on clinical grounds

The predominant objective methods of investigating urinary incontinence involve intraluminal pressure measurements. They are sometimes combined with radiographic and elctromyographic examinations [10]. Usually, however, the examinations are so complicated that they cannot be used in normal clinical practice. However, with "simpler" equipment, such as that used for simulta-

Table 2. Distribution of diagnoses made by urethrocystometry Lund-Malmö Clinics, 1977-1979

Type of incontinence	Number of patients	%
Stress incontinence	214	53.4
Urge incontinence	48	12.0
Mixed incontinence	41	10.2
Urgency-frequency	20	5.0
Neurogenic incontinence	6	1.5
Uncertain incontinence	9	2.2
Normal urethrocystometry	63	15.7
Total	401	100.0

neous urethrocystometry with microtransducers or carbon dioxide cystometry, most patients with urinary incontinence can be examined [9, 11]. The distinction between stress and urge incontinence is of great importance since most unsuccessful operations for stress incontinence are those done on patients in whom urge incontinence is not recognized as the dominant symptom.

The question of detrusor instability as a cause of urinary incontinence has been widely discussed and it is clear that many patients with an "unstable" bladder may not complain of urge incontinence [2]. We found that urethral instability is also a relatively common disorder in patients with urinary incontinence. Neither bladder nor urethral instability can be diagnosed solely on clinical grounds. Our five-year experience with simultaneous urethrocystometry indicates that this technique can be used to advantage both clinically and for research. The technique requires some technical ability and should perhaps be restricted to well-equipped units. With trained personnel a comparatively large number of examinations can be made daily. By comparison with urethrocystometry, carbon dioxide cystometry is a somewhat simpler examination technique but the latter has been criticized as being unphysiological as it involves forced filling of the bladder which can cause artifacts. Thus the number of unstable bladders found by carbon dioxide cystometry is greater than the number found by fluid cystometry [8]. Our comparatively low figure for unstable bladders (8 of 48 urgency incontinence patients), tends to support the criticism of gas cystometry [4], but the use of gas urethrocystometry as a screening method in non-specialized units is a realistic idea. However, with symptom profiles which are not clear-cut or when patients are being considered for surgery for recurrent incontinence, referral to specialized units with access to more sophisticated diagnostic methods, such as urethrocystometry with urethral pressure profile measurement and possibly cineradiography [10], should be considered.

By urethrocystometry, we found that 7.5% of all patients had an unstable urethra (Fig. 1), the figures being 29.1% for patients with urge incontinence, 14.6% for those with mixed incontinence, and about 2% for patients with genuine stress incontinence.

No less than 63 patients (15.7%) of patients complaining of incontinence were in fact continent, with normal urethral pressure profiles and urethrocys-

tometrograms. The discrepancy may have been due to clinical assessment which was too superficial or to the presence of mild and only transient incontinence. The identification of such patients is important because it leads to the avoidance of unnecessary surgery.

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STRESS INCONTINENCE DURING PREGNANCY AND IN PUERPERIUM

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ABSTRACT

A retrospective follow-up investigation dealing with the frequency of stress incontinence was carried out among maternities at the Women's Clinic in Lund over a period of 15 months. Of 1500 newly-delivered women whose interviews were solicited, 1411 responded. Twenty-two percent indicated symptoms of stress incontinence. These were examined gynecologically, including Bonney's test. The material may be divided into four groups according to the onset and type of stress incontinence:

- Onset of stress incontinence prior to pregnancy, in connection with puberty; 8.5 % of the total number of stress incontinents (2 % of the entire material).
- Permanent stress incontinence with onset during pregnancy; 23 % of all stress incontinents (5 % of the entire material).
- Temporary, mild, "physiological" stress incontinence, manifest only during the second part of the pregnancy and disappearing approximately 3 months after delivery. This type of incontinence represents 50 % of all stress incontinents (11 % of the entire material).
- Stress incontinence arising in conjunction with or following parturition; 19 % of all cases of stress incontinence (4 % of the entire material). Of the patients in this group 8 % were temporarily incontinent. Eleven percent (2.3 % of the entire material), represents women suffering from constant incontinence which first appeared in connection with childbirth.

It is more often the case that stress incontinence begins during the first pregnancy rather than during subsequent pregnancies (statistical significance $P \leq 0.05$).

The results indicate that the pregnancy itself and hereditary factors predispose more readily than the parturition trauma to the occurrence of stress incontinence.

INTRODUCTION

Stress incontinence is a common disorder which can arise in women of any age (1,2,8,11). Figures reported with regard to the frequency and incidence of stress incontinence during pregnancy and in puerperium have been at variance (1,2,10). The role of mechanical injury, which often occurs during childbirth, in bringing about stress incontinence in women was emphasized by Malpas in 1949 (7). Other authors have pointed to the pregnancy itself as an important precipitating factor (2).

In this investigation, symptoms of urinary incontinence have been penetrated in a large group of recently-delivered women, utilizing three questionnaires. The objects of the investigation have been

to determine the incidence and frequency of stress incontinence in the patients and to analyze the significance of the parturition parameters in causing stress incontinence.

MATERIALS AND METHODS

All maternity patients delivered over a seven months period at the Women's Clinic in Lund, were provided with a questionnaire containing 21 questions on the subject of possible incontinence difficulty (Table I). Along with the questionnaire was a letter which explained the purpose of the investigation. Replies were submitted in sealed envelopes prior to release of the patients from the clinic, 7-14 days after childbirth.

Table I. Questionnaire 1 (see Materials and Methods)

	Yes	No
1. Do you suffer from involuntary discharge of urine?	___	___
2. Does urine escape during exertion, as, for example, coughing, lifting heavy objects, climbing stairs, etc?	___	___
3. When did this leakage of urine begin? In childhood (that is, before menstruation began), during an earlier pregnancy, during an earlier childbirth, during this pregnancy? During or soon after this childbirth? (Underline which).	___	___
4. Please indicate how many confinements you have had, and in which years these took place. Number of confinements: ___ Years: ___	___	___
5. Indicate whether any of the children were delivered by: vacuum extractor forceps Caesarean section	___	___
6. How many children weighed more than 4 kg at birth?	___	___
7. Did any serious rupture occur to the perineum, vagina, or cervix (neck) of the uterus that required stitches by the doctor?	___	___
8. If you suffered from leakage of urine before any of the confinements, did this leakage become worse during any of the pregnancies or confinements? If so, state during which of the pregnancies or confinements this occurred.	___	___
9. Were you a bedwetter as a child?	___	___
10. Do you now as a grown-up wet the bed?	___	___
11. Do you often have a very strong urge to pass water but are able to hold until you reach a toilet?	___	___
12. Do you often get such a very strong urge that you	___	___

Table I continued

	Yes	No
can <u>not</u> hold until you reach a toilet, but wet yourself?	—	—
13. Do you have to urinate more than 10 times per day?	—	—
14. Do you have to urinate more than twice per night?	—	—
15. Have you before or during pregnancy been treated for bladder catarrh or inflammation of the kidney pelvis, or been operated on for any ailment of the kidneys or lower abdomen? (Underline which).	—	—
16. Does the sound of running water bring forth an urge to urinate?	—	—
17. What is your approximate height: _____ cm	—	—
18. What is your approximate weight: _____ kg	—	—
19. Does your mother suffer from involuntary discharge of urine?	—	—
20. If so, did this begin in connection with pregnancy or confinement, or later? (Underline which).	—	—
21. If you are uncertain as to whether you have leakage or not, you can test yourself in the following manner: When you go to the toilet with a filled bladder (having not passed water for more than 2 hours), stand with your legs wide apart and cough vigorously 5 or 6 times in succession. Check to see if there is any leakage of urine. If there is, check to see if you can contract your muscles and prevent leakage.	—	—
a) Did you have leakage of urine?	—	—
b) Were you able to prevent leakage?	—	—

Of 1500 childbed patients, 1411 responded by filling in the questionnaire. The patients who complained of urinary incontinence difficulty were referred to the clinic's urology specialist who completed the case histories of the patients in question and examined journals, both earlier and current, pertaining to the delivery. The patients were also examined gynecologically, which included Bonney's test.

Six to 12 months after childbirth a more expanded questionnaire containing 30 questions was sent by mail to all those who stated in the first questionnaire that they were troubled by incontinence difficulty (Table II). The objects of this questionnaire were to segregate the temporary from the lasting incontinences arising in connection with pregnancy and childbirth and to determine which of the pregnancies or deliveries had precipitated the patients' difficulty. Ninety percent of those questioned responded to this questionnaire.

Table II. Questionnaire 2 (see Materials and Methods)

	Yes	No
1. Do you suffer from involuntary discharge of urine?	___	___
2. Does this happen every day?	___	___
3. Does this occur during physical activity, or in exertion, such as:		
a) vigorous coughing or heavy lifting?	___	___
b) when climbing or descending stairs, or in rapid movement on level ground?	___	___
4. Does it restrict your social activities or your daily contacts with others?	___	___
5. While in a standing position, does urine escape without your exerting yourself?	___	___
6. When you perform such activities or exertions as those mentioned above, does urine escape without your experiencing a strong urge to pass water?	___	___
7. Are you obliged to wear a sanitary napkin or change underclothing several times a day?	___	___
8. Do you cough a good deal?	___	___
9. Did this involuntary discharge of urine during physical exertion begin:		
a) in childhood (that is, before you began to menstruate)?	___	___
b) after you began to menstruate?	___	___
c) during your first pregnancy?	___	___
(If so, in which month did the leakage begin?)	___	___
d) after your first confinement?	___	___
(If so, when? - underline one of the following):		
Immediately After 1 month 3 to 6 months		
e) during your second pregnancy?	___	___
(If so, in which month did the leakage begin?)	___	___
f) after your second confinement?	___	___
(If so, when? - underline):		
Immediately After 1 month 3 to 6 months		
g) during your third pregnancy?	___	___
(If so, in which month did the leakage begin?)	___	___
h) after your third confinement?	___	___
(If so, when? - underline):		
Immediately After 1 month 3 to 6 months		
i) during your fourth pregnancy?	___	___
(If so, in which month did the leakage begin?)	___	___
j) after your fourth confinement?	___	___
(If so, when? - underline):		
Immediately After 1 month 3 to 6 months		
10. Did this discharge of urine become worse during:		
1st 2nd 3rd etc. pregnancy?		
Immediately after 1st 2nd 3rd etc. confinement?		
(Underline which).		
11. Did you have only temporary leakage of urine during		

Table II continued

Yes No

pregnancy? (1st 2nd 3rd etc.).		
12. Did this leakage of urine stop after childbirth?	_____	_____
- immediately		
- after 1 month		
- after 1 to 3 months		
- after 3 to 6 months		
13. How many confinements have you had?		
14. How many children were delivered by:		
a) vacuum extractor	child's weight:	
b) forceps	child's weight:	
c) Caesarean section	child's weight:	
15. Do you have a burning sensation when passing water?	_____	_____
16. Do you have pains in the bladder area, that is, the area above the pubic hairs?	_____	_____
17. Do you commonly have a very strong urge to pass water but are able to hold until you reach a toilet?	_____	_____
18. Do you commonly get such a very strong urge that you can <u>not</u> hold until you reach a toilet?	_____	_____
19. Do you have to urinate more than 10 times per day?	_____	_____
20. Do you have to urinate more than twice per night?	_____	_____
21. Did any of the above (see questions 15 to 20) begin in connection with pregnancy or childbirth? (Underline)		
Pregnancy no. _____	Childbirth no. _____	
22. Have you been treated for bladder catarrh during the past 2 years?		
23. Have you been treated for inflammation of the kidney pelvis during the past 2 years?	_____	_____
24. Does the sound of running water bring forth an urge to urinate?	_____	_____
25. Do you often have to seek a toilet while you are out shopping?	_____	_____
26. What is your approximate normal weight? _____		
27. What is your approximate height? _____		
28. Does your mother suffer from involuntary discharge of urine?		
29. When did she begin to experience this difficulty?	_____	_____
30. If you are uncertain as to whether you have leakage or not, you can test yourself in the following manner: When you go to the toilet with a filled bladder (having not passed water for more than 2 hours), stand with your legs wide apart and cough vigorously 5 or 6 times in succession. Check to see if there is any leakage of urine. If there is, check to see if you can contract your muscles and prevent leakage.		
a) Did you have leakage of urine?	_____	_____
b) Were you able to prevent leakage?	_____	_____

After approximately the same interval, 6-12 months following delivery, a third questionnaire was sent to 300 women selected at random, who had stated in reply to the first questionnaire that they had not experienced any incontinence difficulty in connection with pregnancy or immediately following childbirth (Table III). The purpose of this third questionnaire was to determine to which extent stress incontinence difficulty arises after a period of weeks or months following delivery.

Table III. Questionnaire 3 (see Materials and Methods)

	Yes	No
1. Do you suffer from involuntary loss of urine when:		
a) coughing vigorously or when lifting heavy objects?	—	—
b) climbing or descending stairs, or in rapid movement on level ground?	—	—
2. Do you lose urine while in a standing position when not exerting yourself?	—	—
3. Do you lose urine if you perform activities or exert yourself, and if so, without you experiencing urgent need or pressure before leakage of urine?	—	—
4. Leakage of urine began: (<u>Underline</u> which)		
a) 1 week to 1 month after childbirth		
b) 1 to 3 months after childbirth		
c) 3 to 6 months after childbirth		

RESULTS

Of the 1500 women who were asked to fill in the first questionnaire, 1411 (94 %) responded. The parity distribution of this material was as follows:

Para-I	541	(38.3 %)
Para-II	611	(43.3 %)
Para-III	205	(14.5 %)
Para-IV	42	(3.0 %)
Para-V	7	(0.9 %)
Para-VI	4	
Para-IX	1	
	1411	

Three hundred twenty-one patients (22.7 %) reported stress incontinence difficulty in the first questionnaire. The more extensive second questionnaire was answered by 306 (95 %) of the 321 stress

incontinent patients.

The onset of stress incontinence in relation to pregnancy may be seen in Table IV. In 26 patients (8.5 % of the incontinent women who replied to the second questionnaire), stress incontinence had begun prior to pregnancy, while 222 women (72.5 %) stated that their distress began during pregnancy. A smaller number, 58 (19.0 %), placed the onset of their stress incontinence difficulty after childbirth. Among these women, incontinence ceased in nearly half of the cases (25 patients) a few weeks after delivery, while 33 patients remained incontinent 6-12 months after delivery.

Table IV. Onset of stress incontinence correlated to pregnancy and parturition in 306 patients (2nd questionnaire)

Before Pregnancy	26		8.5 %
During Pregnancy	222		72.5
Manifest		69	22.5 %
Temporary		153	50.0
At Delivery	58		19.0
Manifest		33	11.0
Temporary		25	8.0
	<u>306</u>		<u>100.0 %</u>

In cases where stress incontinence began during pregnancy or soon after delivery (280 patients), partograms and journals were examined with respect to duration of labor, frequency of the use of instruments, and the weight of the infants.

Of 222 patients whose stress incontinence began during pregnancy, 135 occurred during the first pregnancy. The difference in frequency between Para-I and Para-II is statistically significant ($p < 0.05$). Altogether, 153 of 222 patients had incontinence of a mild physiological type (Fig. 1). This type of stress incontinence began during the second part of the pregnancy and ceased approximately 3 months after delivery in practically all cases.

The difference in the frequency of physiological stress incontinence between first maternities and subsequent maternities is not statistically significant.

Of 222 patients who experienced the onset of stress incontinence during pregnancy, 69 had permanent stress incontinence (Fig. 2). Most of these patients stated that onset occurred early in the

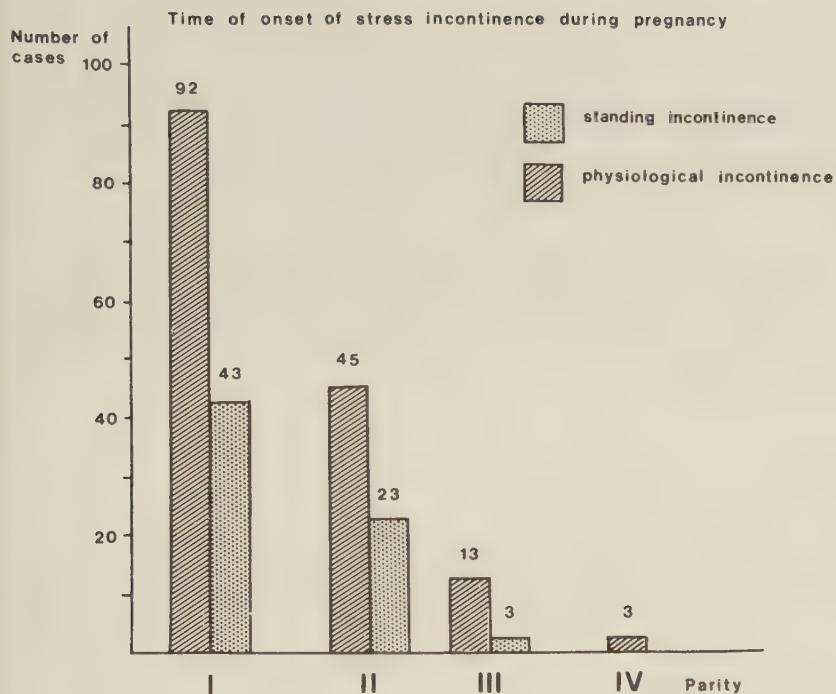


Fig. 1. Lasting and physiological stress incontinence with onset during pregnancy in 222 patients (reply to 2nd questionnaire).

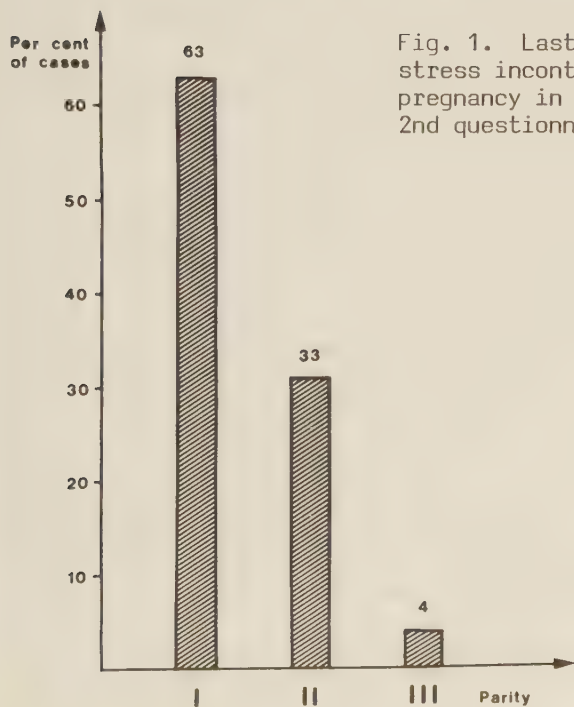


Fig. 2. Correlation between 1st, 2nd, or 3rd pregnancy and onset of lasting stress incontinence (reply to 2nd questionnaire).

first pregnancy. The difference in frequency between Para-I and Para-II here is statistically significant ($p \leq 0.05$).

Of the 300 patients without urinary incontinence who were interviewed in the third questionnaire, 264 (88 %) responded. Sixteen of these (6 %) described mild stress incontinence symptoms (1st degree) (15) 1-3 months after childbirth.

Twenty percent of the patients with urinary incontinence replied that their mothers were troubled by stress incontinence or had been operated on for this disorder. The corresponding proportion in a control group was 4 %. The incidence is five times greater in the incontinence group and the difference is statistically significant ($p < 0.001$).

DISCUSSION

Earlier works dealing with the frequency and the onset of stress incontinence in connection with pregnancy and childbirth have produced conflicting results (1,2,10). The purpose of a triple questionnaire applied to the same population of women delivered during a 7-month period was to determine the frequency of stress incontinence, both permanent and temporary, during pregnancy, childbirth and puerperium, and to relate the onset of stress incontinence to various parturition parameters and the number of pregnancies.

Of the women in our investigation, 22.7 % stated that they were troubled by stress incontinence which had begun during pregnancy or subsequent to childbirth. A considerably higher figure was asserted in 1960 by Francis (2) who reported an incidence of 67 %. That investigator found no onset of stress incontinence in the puerperium. Beck, on the other hand, in an investigation in 1965 (1) found that 14 % of the patients delivered indicated onset of stress incontinence in the puerperium. In our investigation 300 patients were questioned 6-12 months after parturition (3rd questionnaire) as to the presence of stress incontinence difficulty, which they had denied shortly after delivery (1st questionnaire). Sixteen patients (6 %) stated at that time that their stress incontinence difficulty had begun in the puerperium. This figure too is considerably lower than that reported by Beck (1).

Of the 306 stress incontinence patients, 8.5 % (2 % of the entire material), stated that the disorder first appeared in connection with puberty (Table IV). Nemir (8) found in 1956 that every other young girl suffered from temporary stress incontinence, but only 5 % of these had constant incontinence difficulty.

Two hundred twenty-two of our patients (72.5 %), indicated that their stress incontinence disorders began during pregnancy. The

majority were mild degrees of stress incontinence which had begun during pregnancy and the symptoms disappeared 3 months after delivery. Hormonal factors may have some significance here since the hormone condition in women returns to normal at approximately this point after childbirth. Urethral function might very well be affected by estrogen as well as by progesterone. The influence of estrogen and progesterone upon smooth muscle tissue has been studied earlier (3,4). Estrogen is considered to increase the sensitivity of alfaadreno receptors in the smooth musculature of the urethra (3) and may possibly have a positive effect upon the continence parameters (9). Interestingly, evidence of the existence of estradiol receptors in the human female urethra has recently been presented (6). These observations provide further support for the view that the role of estrogens in urethral pathophysiology is important.

Patients with permanent stress incontinence constitute an important group in our investigation, comprising 7.2 % of the entire material. Only 33 patients, or 2.3 % of the entire material and 11 % of all patients with stress incontinence, indicated that their permanent incontinence condition first appeared in connection with childbirth. A considerably higher figure (14 %) was reported earlier by Beck (1). This suggests that the parturition trauma itself played a less decisive role among our patients as a cause of stress incontinence. In our investigation an analysis of various parturition parameters (Table V) has been made for the group of patients who were incontinent and for a control group of equal size. No significant differences were observed between these two groups with respect to duration of labor, the prenatal position of the head of the child, its weight, or the manner of delivery.

Table V. Statistical analysis of parturition parameters in 280 deliveries of stress incontinent women compared with an equal number of deliveries of healthy, continent women selected at random.

	Incon- tinence	Control	Signifi- cance
Total duration of labor > 12 h	6	4	N.S.
Duration of second stage > 1 h	25	39	N.S.
Deflection of the fetal head	17	8	N.S.
Spontaneous delivery	234	253	N.S.
Instrumental delivery	14	12	N.S.
Caesarean section	22	15	N.S.
Birth weight > 4 kg	46	66	N.S.

In 23 % of the permanent stress incontinent cases (4.9 % of the entire material), onset occurred during pregnancy. The majority of the patients who indicated onset of stress incontinence during pregnancy experienced their difficulty during the first pregnancy. The difference in frequency between Para-I and Para-II is statistically significant ($p \leq 0.05$), unlike the patients with temporary stress incontinence where no such significance is evident.

Hereditary factors seem to have a bearing upon the appearance of stress incontinence. In our investigation we found that the incidence of stress incontinence in the patients' mothers was five times greater in the incontinence group than in the control group.

There may be reason to reappraise the role of the parturition trauma in causing permanent stress incontinence. The pregnancy as such, including hormonal factors and predisposing hereditary factors, appears to be more influential in bringing about permanent stress incontinence than the childbirth itself.

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POSTPARTUM INCONTINENCE

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ABSTRACT

From a questionnaire survey dealing with urinary incontinence during pregnancy and after childbirth 62 women were randomly selected. These women underwent simultaneous urethrocystometry including urethral profile measurement 7-14 days after parturition. From the case history two groups of patients could be distinguished.

One group consisted of women who experienced only occasionally urine leakage after delivery. Pressure recordings in these previous patients were normal, moreover the urethral closure pressure was positive, also at cough provocations. The urethral length and pressure were similar to that found in continent females. The other group of patients reported stress incontinence of a more serious and permanent nature; the symptoms did not disappear after delivery. In all these women negative urethral closure pressures were recorded at cough provocations and simultaneously leakage of urine from the urethra was observed. In addition the urethral length was shorter and urethral resting pressure lower than that recorded in the first group of patients. The reversible symptoms in the first group of women may be a consequence of the pressure exerted by the uterus upon the bladder at coughing combined with a hormonal relaxation of the urethral suspension. In the second group, the enduring symptoms suggest irreversible damage to the urethra and its suspension system during pregnancy.

INTRODUCTION

Due to the proximity of the lower urinary tract to inner genitalia in women, these two organs often affect one another when a pathophysiological condition exists. Thus, for example, pregnancy and childbirth are looked upon as possible causes of various types of urinary incontinence.

Several investigators have studied the anatomy and physiology of the bladder during pregnancy and delivery (10-12). Such studies have been concerned primarily with radiological determination of the positions of the uterus and bladder, while no functional investigations of the bladder or the urethra are available.

The purpose of the present investigation was to examine, by means of simultaneous urethrocystometry (14), the urethra and bladder in women who have recently given birth and who have indicated symptoms of stress incontinence during pregnancy or immediately fol-

lowing parturition.

PATIENTS AND METHODS

Patients

Sixty-two patients participated in the investigation. After having informed the women in detail as to the examination techniques and purposes, we secured their willing cooperation.

The patients who took part in the investigation were selected at random among a number who, in response to a questionnaire survey dealing with urinary incontinence, had stated that they had experienced urine leakage at one time or another during pregnancy or in puerperium. The questionnaire was designed to penetrate the frequency of urinary incontinence among pregnant women and women recently confined. The results of the survey are shown separately (7).

Measurements of the patients were carried out 7-14 days following parturition. Two of the patients were delivered by cesarean section. Sixty were delivered vaginally, without complication. The parity distribution was as follows: para I, 21 patients; para II, 22 patients; para III, 16 patients, and para IV, 3 patients.

The average age of the patients was 31.5 years (range 18-44 years), the average weight of the children at birth was 3,100 g (range 1,300-4,630 g).

Methods

All patients were examined by means of a technique described earlier for simultaneous urethrocystometry including urethral pressure profile measurement (14). A schematic description of the method and the parameters registered are shown in figure 1. The patients were examined in both a supine and a standing position. The bladder was filled with 200 ml physiological saline solution at body temperature. After three urethral profile measurements, simultaneous urethrocystometry was performed under repeated cough provocation.

Definitions

The definitions given are in general agreement with those recommended by ICS in 1977 (1).

Urethral pressure: the pressure within the urethra in relation to the atmospheric pressure.

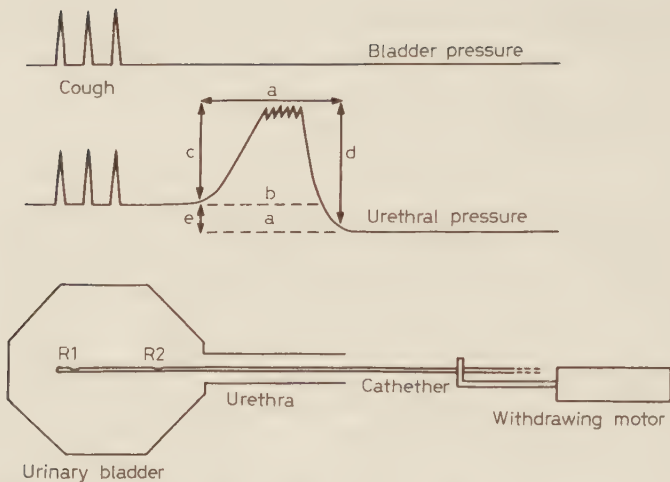


Fig. 1. The upper panel represents an urethral pressure profile with definitions of the recorded parameters. The lower panel is a schematic diagram of the microtransducer catheter in position. The bladder pressure is recorded from receptor 1 (R1) whereas receptor 2 (R2) records intraurethral pressure. Before withdrawing the catheter the patient is requested to cough, thereby providing a check on the function of the equipment (upper panel, left). During continuous withdrawal of the catheter, R2 records the urethral pressure profile (upper panel, right). In simultaneous urethrocystometry the withdrawal is halted when R2 reaches the high-pressure zone of the urethra. a = Absolute length of urethra; b = functional length of urethra; c = closure pressure; d = maximal urethral pressure, and e = bladder pressure.

Intravesical pressure: the pressure within the bladder in relation to the atmospheric pressure.

Urethral pressure profile; a continual recording of the intraurethral pressure from the internal to the external meatus.

Urethral closure pressure: the intraurethral pressure minus the bladder pressure.

Functional length of the urethra: that portion of the urethra where the intraluminal pressure exceeds the bladder pressure.

Absolute length of the urethra: that portion of the urethra where the intraluminal pressure exceeds the atmospheric pressure.

Stress incontinence: involuntary urine leakage occurring when

intravesical pressure exceeds the maximum urethral pressure in the absence of detrusor activity.

Urinary continence: absence of urine leakage and positive urethral closure pressure at moderate or forceful coughing in conjunction with simultaneous urethrocystometry. (Bladder pressure increase approximately 70 cm H₂O.) Lengths are given in millimeters, pressures are given in cm H₂O (1).

Statistical Evaluation

Student's t test has been used in calculating statistical differences. Values where $p \leq 0.05$ are considered to be statistically significant.

RESULTS

From the questionnaire and the clinical examination, including Bonney's test, two patient groups could be distinguished:

Group I. Subjective leakage on infrequent occasions during pregnancy in connection with vigorous exertion, as, for example, heavy coughing. No difficulty after parturition. These patients had no earlier case histories of stress incontinence.

Group II. Subjective persistent urinary incontinence or frequent stress incontinence commencing during the latter half of pregnancy. Continued difficulty after delivery.

There were 35 patients in the first group, 27 in the second. The results of the pressure measurements for both groups are shown in table I. As can be seen, the maximum urethral pressure in supine position was 82 cm H₂O (range 69-102 cm H₂O in group I and 48 cm H₂O (range 24-72 cm H₂O) in group II. The statistically significant difference: $p \leq 0.001$. Bladder pressures were nearly identical in the two groups, i.e., 10 cm H₂O in group I and 11 cm H₂O in group II. Accordingly, the closure pressure was substantially lower in group II (38 cm H₂O) than in group I (72 cm H₂O). $p \leq 0.001$.

In the standing position the maximum urethral pressure increased in both groups (group I 100.0 cm H₂O, group II 68 cm H₂O, $p \leq 0.001$). The increase in bladder pressure in the standing position was similar for both groups, approximately 18 cm H₂O. In examinations involving the cough profile, i.e., pressure profile recording during repeated coughs, the urethral closure pressure in group I remained positive at all times during moderate to vigorous coughing (fig. 2). No additional objective leakage was observed. In measurement of

Table 1. Mean values, standard deviation, and statistical significance in patients with stress symptoms during pregnancy only and in patients incontinent during pregnancy and in puerperium. Urethral profile and simultaneous urethrocytometry 7 to 14 days after delivery

Variable	Group	Supine position		Standing position	
		mean $\pm$ SD	significance	mean $\pm$ SD	significance
Absolute length of urethra, mm	I	33.37 $\pm$ 3.753	0.01 < p $\leq$ 0.05 (t = 2.10)	37.20 $\pm$ 6.680	NS (t = 0.47)
	II	31.14 $\pm$ 4.400		36.26 $\pm$ 4.890	
Functional length of urethra, mm	I	27.04 $\pm$ 3.818	p $\leq$ 0.001 (t = 3.75)	29.60 $\pm$ 4.300	NS (t = 1.68)
	II	23.60 $\pm$ 3.389		26.35 $\pm$ 4.444	
Maximum urethral pressure, cm H ₂ O	I	81.80 $\pm$ 9.191	p $\leq$ 0.001 (t = 11.78)	99.96 $\pm$ 10.362	p $\leq$ 0.001 (t = 6.72)
	II	48.81 $\pm$ 12.105		67.76 $\pm$ 13.731	
Bladder pressure, cm H ₂ O	I	10.02 $\pm$ 2.449	NS (t = 0.75)	29.24 $\pm$ 4.590	NS (t = 0.54)
	II	10.53 $\pm$ 2.787		28.32 $\pm$ 4.681	
Closure pressure, cm H ₂ O	I	71.73 $\pm$ 9.509	p $\leq$ 0.001 (t = 12.04)	70.72 $\pm$ 8.720	p $\leq$ 0.001 (t = 4.46)
	II	38.27 $\pm$ 11.774		38.94 $\pm$ 12.328	
Maximum pressure point of urethra, mm	I	15.56 $\pm$ 2.242	0.01 < p $\leq$ 0.05 (t = 5.65)	17.40 $\pm$ 4.427	p < 0.001 (t = 3.70)
	II	12.46 $\pm$ 2.063		13.56 $\pm$ 1.948	

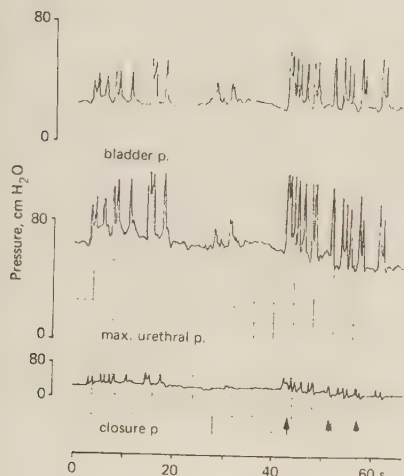


Fig. 2.

Simultaneous urethrocystometry in standing position for a 20-year-old para I 1 week after parturition. Urethral closure pressure positive at repeated coughing. No evidence of leakage (bladder content 200 ml). Cough indicated by arrows.

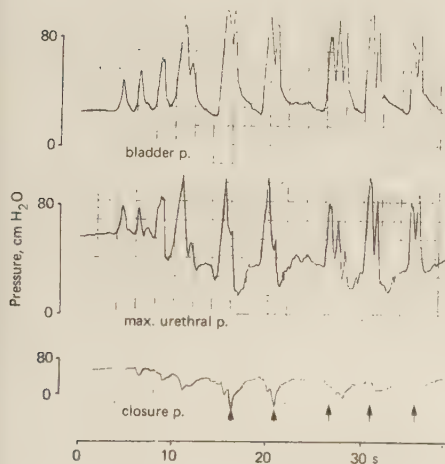


Fig. 3.

Simultaneous urethrocystometry in standing position for a 22-year-old para I 10 days after parturition. Urethral closure pressure negative at repeated coughing. Simultaneous urine leakage (bladder content 200 ml). Cough indicated by arrows.

the cough profile a closure pressure around zero was consistently observed in group II. Leakage in these patients was apparent. Some had only a dripping leakage at coughing in supine position but leaked quite considerably when coughing in a standing position (fig. 3). Bonney's test was positive in all of the patients in group II.

The results of the recording of the functional urethral length are shown in table I. As can be seen, the functional urethral length in group I was 27 mm in supine position and 29.6 mm in standing position. The corresponding values in group II were 23.6 and 26.3 mm, respectively. The difference is significant ($p \leq 0.001$).

DISCUSSION

The sharp differences between group I and II with respect to intra-urethral pressure in both supine and standing position (table I) suggest that the females of group I may be considered as healthy continent subjects, while the patients of group II displayed values similar to those presently seen among stress-incontinent patients (2,3,5,9,13). The suggestion that group I included women with very mild "physiological" stress incontinence is also supported by the fact that the functional length of the urethra is in conformity with that recorded in continent women (4,6,8). The functional urethral length in group II was 23.6 mm, while stress-incontinent women in the aforementioned study (5) had a functional urethral length of 21.4 mm. These values are in good correlation with those recorded for women troubled by enduring stress incontinence post partum.

Looking at urethral closure pressure, we found a striking similarity by earlier investigations (4,5). Thus, group I had a closure pressure of 72 cm H₂O, while continent women in earlier measurements had a closure pressure of 74 cm H₂O. This supports the assumption that group I included women with very mild stress incontinence and might be considered as being almost healthy or continent females. Subjectively, these patients also described very mild stress incontinence symptoms which could not be verified at the urethrocystometries since the urethral closure pressure at cough remained positive in all patients. If one compares group II with the stress-incontinent group in the aforementioned investigation, the closure pressure was 38 and 56 cm, respectively (5). This seems to indicate that there were genuinely stress-incontinent women in group II, probably with lasting incontinence difficulties. Urethral closure pressure also decreased to or below zero at coughs in those patients (fig. 3).

Stress incontinence during pregnancy might be due to hormonal effects on the lower urinary tract and/or to an increased uterine pressure upon the bladder. These effects should be regarded as reversible. The lasting stress incontinence which not seldom occurs after completed pregnancy must, therefore, be the result of a damage to the urethra and its suspension system. The nature of this damage is still unclear.

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Urodynamic studies in normal pregnancy and in puerperium

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Fourteen primiparas (11 pregnant for the first time, and three with a history of one abortion) were examined during pregnancy to elucidate changes in parameters of importance for maintenance of urinary continence. Urethral pressure profile measurements and simultaneous urethrocystometry were carried out in the beginning of pregnancy (weeks 12 to 16), in the thirty-eighth week, and 5 to 7 days after delivery. Both the absolute and functional lengths of the urethra were found to increase throughout pregnancy by median values of 6.7 and 4.8 mm, respectively. Also, the maximum urethral pressure increased gradually during pregnancy, returning within 1 week after delivery to almost the same value as at the beginning of pregnancy. The urethral closure pressure also increased throughout pregnancy. Thus, the results of the investigation revealed that the physiologic changes which took place within the urethra during pregnancy were to advantage from the standpoint of maintaining continence. (AM. J. OBSTET. GYNECOL. 137:696, 1980.)

IT HAS long been observed that pregnancy and childbirth bring about a predisposition to such urinary disorders as stress incontinence and bladder retention. The physiology of the bladder during pregnancy was interpreted as early as 1938, by Muellner.⁸ However, studies establishing a connection between pregnancy, childbirth, and stress incontinence, were first conducted in 1959, by Francis,⁵ who found stress incontinence in 67% of pregnant patients. In 1,000 random patients, Beck and Hsu,⁶ in 1965, reported 64.5% to be incontinent during pregnancy, and 14.1% in the puerperium.

Most studies on urinary incontinence during pregnancy have been based on the patient's subjective report and/or simple cystometry. By these means it is not possible to evaluate accurately and objectively changes in important continence parameters. A new pressure recording instrument⁹ affords the possibility of de-

termining the bladder pressure, the urethral pressure, the functional length of the urethra, and the urethral closure pressure during pregnancy and after childbirth. Using this device, we examined a number of clinically healthy and continent women during pregnancy and after childbirth. This report presents our findings.

Material and methods

Fourteen women participated in the study. After carefully explaining to the women the examination and the registration techniques, we secured their permission to carry out the investigation in the manner outlined below. Of the 14 registered participants, 11 were pregnant for the first time. Three of them had a history of one earlier abortion (ninth to twelfth weeks). No history of urologic disease was found in any of the patients. Urine cultures were negative.

The first registration was made during the twelfth to sixteenth weeks. The second registration took place during the thirty-eighth week, and the third registration was made 5 to 7 days after childbirth. All deliveries were vaginal. The average delivery took place at 40.5 weeks, with a range from 39 to 42 weeks. The average period of labor was 9 hours. As for analgesia, nine patients received epidural anesthesia, and five, blockage of the pudendum. Six of the patients underwent perineotomy, and two were delivered by means of vac-

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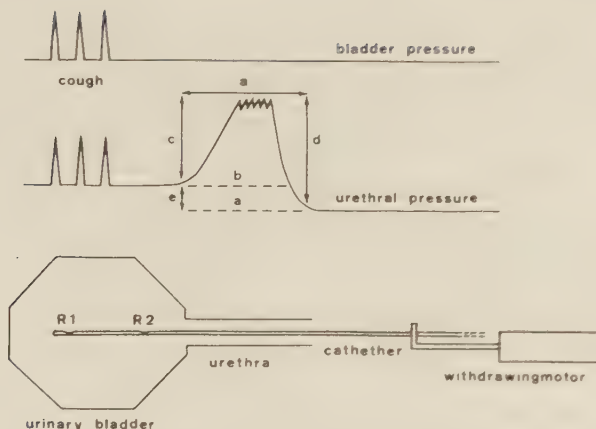


Fig. 1. Pressure recording technique and recorded parameters. The bladder and urethral pressures are recorded from two microtransducers, R1 and R2, attached to a Dacron catheter. Initially, both transducers are located within the bladder. Coughing indicates equal transmission of pressure from both transducers, as seen from the two tracings at the top of the figure. The catheter is then withdrawn at a constant speed, and thereby the urethral pressure profile is obtained. From this profile the following parameters can be calculated: (a) the absolute urethral length; (b) the functional urethral length; (c) the urethral closure pressure; (d) the maximum urethral pressure; and (e) the bladder pressure.

Table I. Average values for measurements made 12 to 16 weeks prior to delivery, during the thirty-eighth week, and 5 to 7 days after delivery, together with an indication of the statistical significance between the first measurement and the second and third measurements, respectively*

Variable	12 to 16 Weeks preceding childbirth	Thirty-eighth week	5 to 7 Days after childbirth
Absolute length of urethra (mm)	36.3 ± 5.13	43.0 ± 6.34 $p \leq 0.001$	32.0 ± 3.61 $0.001 < p \leq 0.01$
Functional length of urethra (mm)	30.3 ± 4.63	35.1 ± 5.12 $p \leq 0.001$	27.6 ± 3.69 $0.01 < p \leq 0.05$
Maximum urethral pressure (cm H ₂ O)	70.0 ± 14.94	93.0 ± 17.29 $p \leq 0.001$	69.0 ± 14.29 NS
Bladder pressure (cm H ₂ O)	9.0 ± 2.94	20.0 ± 3.03 $p \leq 0.0001$	9.0 ± 2.41 NS
Closure pressure (cm H ₂ O)	61.0 ± 13.59	73.0 ± 17.51 $0.001 < p \leq 0.01$	60.0 ± 14.41 NS

NS = Not significant.

*Statistical significance according to Student's *t* test for paired observations.

uum extractor. Thirteen of the infants were delivered in a crouched crown passage position, and one in an open cranial passage position. The average weight of the infants at birth was 3,700 grams, with a range from 3,130 to 4,060 grams. All patients were of normal weight before pregnancy (average height, 1.68 cm; average weight, 58 kilograms). Increases in weight during pregnancy averaged 12.3 kilograms.

Registration techniques. All patients were examined according to a technique described earlier for simultaneous urethrocystometry, including measurement of the pressure profile of the urethra.⁹ A schematic description of the methodology employed, as well as the

parameters recorded, is shown in Fig. 1. The patients were examined in the supine position, with the bladder containing 200 ml of physiologic saline solution. After measurement of the urethral profile, simultaneous urethrocystometry under repeated cough provocation was performed with the patient both supine and standing (Fig. 4). Urine cultures were remitted at each examination. After each examination, continence was tested with the patient in a standing position with repeated coughing.

The definition of continence parameters is in general agreement with the standards established by International Continence Society in 1977.¹

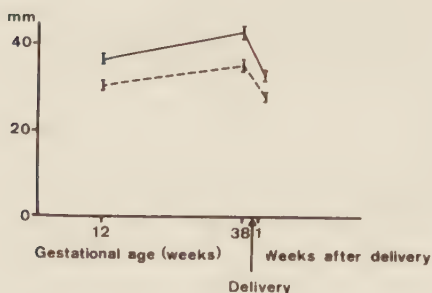


Fig. 2. Changes in absolute urethral length (continuous line) and functional urethral length (dashed line) during pregnancy and puerperium.

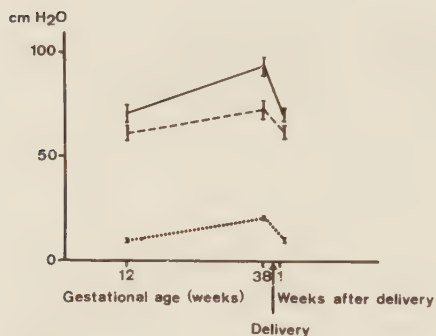


Fig. 3. Changes in maximum urethral pressure (continuous line), urethral closure pressure (dashed line), and bladder pressure (dotted line) during pregnancy and the puerperium.

Results

Pressure measurement results are shown in Table 1 and Figs. 2 and 3. As can be seen, the absolute length of the urethra increased from 36.3 mm at the beginning of the pregnancy to 43 mm in the thirty-eighth week, decreasing thereafter to 32 mm by one week after delivery. These changes are statistically significant ($p \leq 0.001$ and $0.001 < p \leq 0.01$, respectively). The functional length of the urethra (Fig. 2) increased from 30.3 mm at the beginning of the pregnancy to 35.1 mm in the thirty-eighth week, and decreased to 27.6 mm one week after delivery. These changes are statistically significant ($p \leq 0.001$ and $0.01 < p \leq 0.05$, respectively). The changes in the maximum urethral pressure are

shown in Fig. 3. As seen, a marked increase in the maximum urethral pressure occurred at the end of the pregnancy (from 70 to 93 cm H₂O). This difference is statistically significant ($p \leq 0.001$). After delivery the urethral pressure declined to nearly the same value as at the beginning of pregnancy, 69 cm H₂O.

Bladder pressure (Fig. 3) increased substantially, from 9 to 20 cm H₂O toward the end of pregnancy (statistically significant $p \leq 0.001$), and returned to its initial value, 9 cm H₂O, after delivery. As a result of the changes in the pressures of the urethra and the bladder, the urethral closure pressure changed, as shown in Fig. 3. The closure pressure at the first registration was 61 cm. It increased to 73 cm H₂O at the second registration (statistically significant $0.001 < p \leq 0.01$), returning subsequently at the third registration to almost the same value as at the beginning of pregnancy (60 cm H₂O).

The position of the maximum pressure zone of the urethra (Fig. 1) changed somewhat during pregnancy. At the first registration it lay 14 mm from the internal meatus; at the second it was 16 mm from the internal meatus, and at the third, 14 mm from the internal meatus. The closure pressure of the urethra was positive under cough provocation in all 14 patients at the time of all three registrations (Fig. 4).

Comment

Elasticity of all urinary passageways seems to be increased during pregnancy. The oft-observed dilatation of the pelvis renalis, ureter, and bladder has been presumed to be due, in part, to a hormonal reduction of the tone of the smooth musculature.⁴ As early as 1938, Muellner⁴ proved that the capacity of the bladder increases during pregnancy, and that a loss of bladder tone often occurs toward the end of pregnancy. In 1960, Francis⁶ established that bladder capacity becomes reduced in the final weeks of pregnancy as the fetus' head begins to occupy the pelvis minor.

In a preliminary report, Clow³ examined the effect of different body positions on the functions of the bladder and the urethra in normal pregnancy. An increase in intravesical pressure was found throughout the pregnancy, and the functional length of the urethra sometimes increased in the erect posture.

The enlargement of the uterus during pregnancy places an added burden upon the surrounding organs in the pelvis minor, particularly upon the bladder. Doubling of bladder pressure from 9 cm H₂O at the first registration to 20 cm H₂O in the thirty-eighth week indicates a reduction in bladder capacity and increased demands on the closure ability of the urethra. The

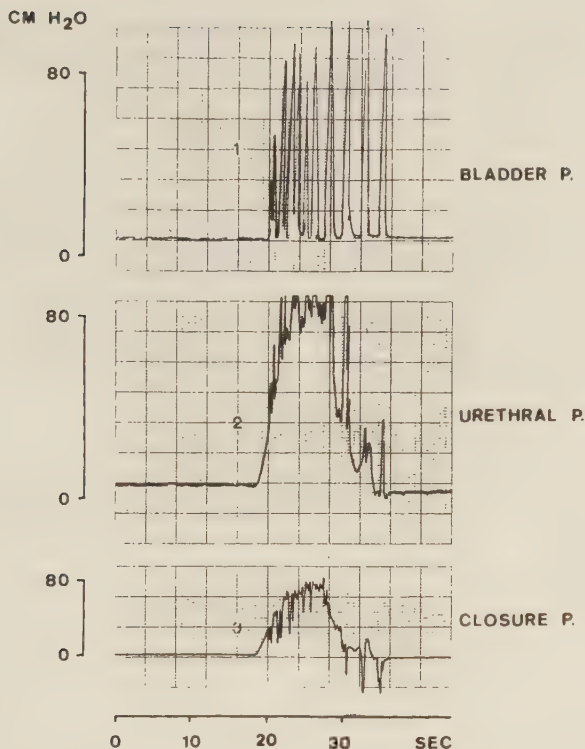


Fig. 4. Cough pressure profile from one of the patients. Compare this figure with Fig. 1. During withdrawal of the catheter, the patient was asked to cough intermittently. This procedure served as a dynamic test of continence. By electronic subtraction in a special amplifier the closure pressure, i.e., the urethral pressure minus bladder pressure, was obtained throughout the recording. As seen in the bottom tracing, the closure pressure was positive within a large part of the urethra. For physical reasons, a positive closure pressure indicates continence. No signs of urinary leakage was observed during the recording.

changes which we were able to observe in the urethral parameters must then be regarded as positive in this respect.

The importance of the length of the urethra in maintaining continence was first pointed out by Lapides and associates⁷ in 1960. They considered that a long urethra contributes to continence. We found that the absolute and functional lengths of the urethra increased by 6.7 and 4.8 mm, respectively, from the twelfth to the thirty-eighth week, in order to compensate for the increased bladder pressure. We also found that the maximum intraluminal pressure of the urethra increased

by 23 cm H₂O from the twelfth to the thirty-eighth week.

Another important finding was that, as a result of the changes in the urethral and bladder pressures, the closure pressure of the urethra increased on an average of 12 cm H₂O from the twelfth to the thirty-eighth week of gestation, i.e., an overcompensation of continence ability occurred among our patients. Continence was also good, as evidenced by the fact that closure pressure remained positive throughout the entire period of pregnancy, even under provocation by heavy coughing (Fig. 4).

Against the background of the findings set forth here for healthy continent women, it will be of great interest to pursue the question of the extent to which the measurement parameters described may deviate in

stress-incontinent women during pregnancy or in women who acquire symptoms of stress incontinence during pregnancy. Such studies are in progress.

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COMPARATIVE URODYNAMIC STUDIES OF CONTINENT AND STRESS INCONTINENT
WOMEN IN PREGNANCY AND IN PUERPERIUM

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Key Words: Stress incontinence - Simultaneous urethro-cystometry -
Pregnancy - Puerperium

ABSTRACT

Twelve pregnant women were examined by urethral pressure profile measurement and simultaneous urethro-cystometry early in pregnancy (weeks 12-16), in the 38th week and 5 to 7 days after delivery. All patients reported symptoms of stress incontinence starting in an early gestational age. Compared to measurements obtained earlier in 14 continent healthy females it was found that the stress incontinent women had a shorter urethral length. Furthermore, no increase in urethral length during pregnancy was registered among the stress incontinent women which was the case among the continent women. In contrast to the continent women, the incontinent patients had a low urethral closure pressure at rest and it did not appear to increase sufficiently to compensate the progressive increase in bladder pressure during the continued pregnancy. As a result the urethral closure pressure in the stress incontinent females therefore became more and more negative at stress situations as pregnancy progressed resulting in an increased leakage of urine at the same time.

INTRODUCTION

In a previous study we investigated at different time intervals during pregnancy healthy continent women by urethrocystometry and urethral pressure profile measurement (1). In these women we found a "physiological" increase of urethral length and pressure as pregnancy progressed. In this way the maximum urethral pressure compensated the successively increasing bladder pressure resulting as a consequence of the enlargement of the uterus, thereby permitting continence to be maintained. One week after delivery urethral length and pressure returned to almost the same values as at the beginning of the pregnancy.

In the present study examinations were conducted among a group of pregnant women who reported symptoms of stress incontinence starting very early in pregnancy. The diagnosis was confirmed by simultaneous urethro-cystometry in the same manner as in the earlier mentioned study (1). The purpose of the present investigation was to penetrate whether a variance existed in important parameters for maintaining continence, i.e. urethral length, urethral pressure, and bladder pressure, between the current stress incontinent patients and the healthy, pregnant women examined earlier.

MATERIALS AND METHODS

Twelve women (age 19-34 years) participated. They were referred by the prenatal clinics for specialist examination after having indicated incontinence difficulty in connection with the initial consultation with a physician to establish pregnancy. According to their own narrative the patients were not incontinent before pregnancy. They reported symptoms of stress incontinence very early in pregnancy. All patients remained incontinent post partum. Of the 12 patients examined, seven were pregnant for the first time, four for the second time, and one for the third time. The first pressure recording was made during the 12th - 16th week, the second during the 38th week, and the third registration five to seven days after parturition. The fetal head with recordings at 38th week was found in all patients above the pelvis, and was therefore mobile. All patients were delivered vaginally, without complication. Surgical interventions were therefore not required in any case. Deliveries occurred on the average during the 40th week, with a range of 39 to 41 weeks. The average duration of labor was eight hours (range 4-18 hours). Five patients received epidural anesthesia and one blockage of the pudendum. Eleven of the children delivered had a vertex presentation, whereas one had a breech presentation. The average weight of the children at birth was 3550 g (range 2520-4110 g). All of the patients were of normal height and weight before pregnancy (average height 167 cm; average weight 60 kg). Weight increase during pregnancy averaged 11.8 kg.

REGISTRATION TECHNIQUE

All of the patients were examined by electronic simultaneous urethro-cystometry including urethral pressure profile measurements (1,2). A schematic description of the methodology employed as well as the parameters recorded is shown in Fig. 1. All patients were examined in the supine position (six in both supine and standing), with a bladder content of 200 ml physiological saline solution (37°C). After three urethral pressure profile recordings, simultaneous urethro-cystometry was performed, both at rest and under repeated cough provocation, in supine and standing position (Fig. 2 and Fig. 3).

Urine cultures were remitted at each examination.

Definitions of the recorded continence parameters are in general agreement with the standards established by I.C.S. in 1977 (3).

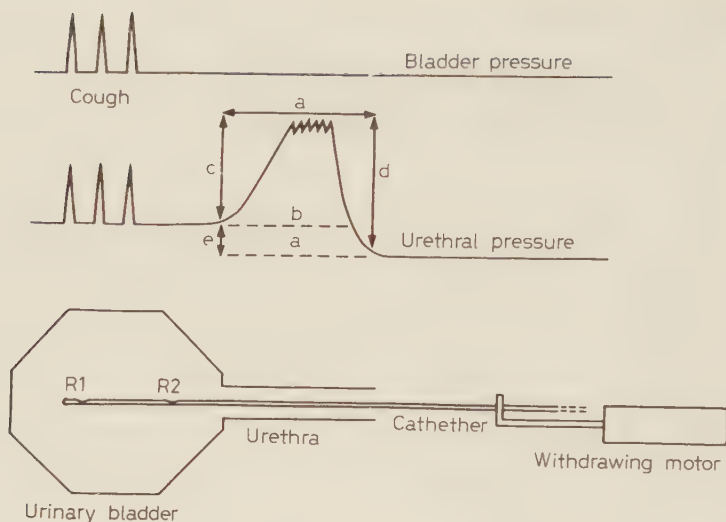


Fig. 1. The upper panel represents an urethral pressure profile with definitions of the recorded parameters. The lower panel is a schematic diagram of the recording microtransducer catheter in position. The bladder pressure is recorded from receptor 1 whereas receptor 2 records intra-urethral pressure. Before withdrawal of the catheter the patient is requested to cough, thereby providing a check on the function of the equipment (upper panel, left). During continuous withdrawal of the catheter, receptor 2 records the urethral pressure profile (upper panel, right). In simultaneous urethro-cystometry the withdrawal is halted when receptor 2 reaches the high pressure zone of the urethra. By electronic subtraction in the amplifier the urethral closure pressure, i.e. urethral pressure, bladder pressure is obtained.

Letters:

- a) absolute length of urethra,
- b) functional length of urethra,
- c) closure pressure,
- d) maximal urethral pressure,
- e) bladder pressure.

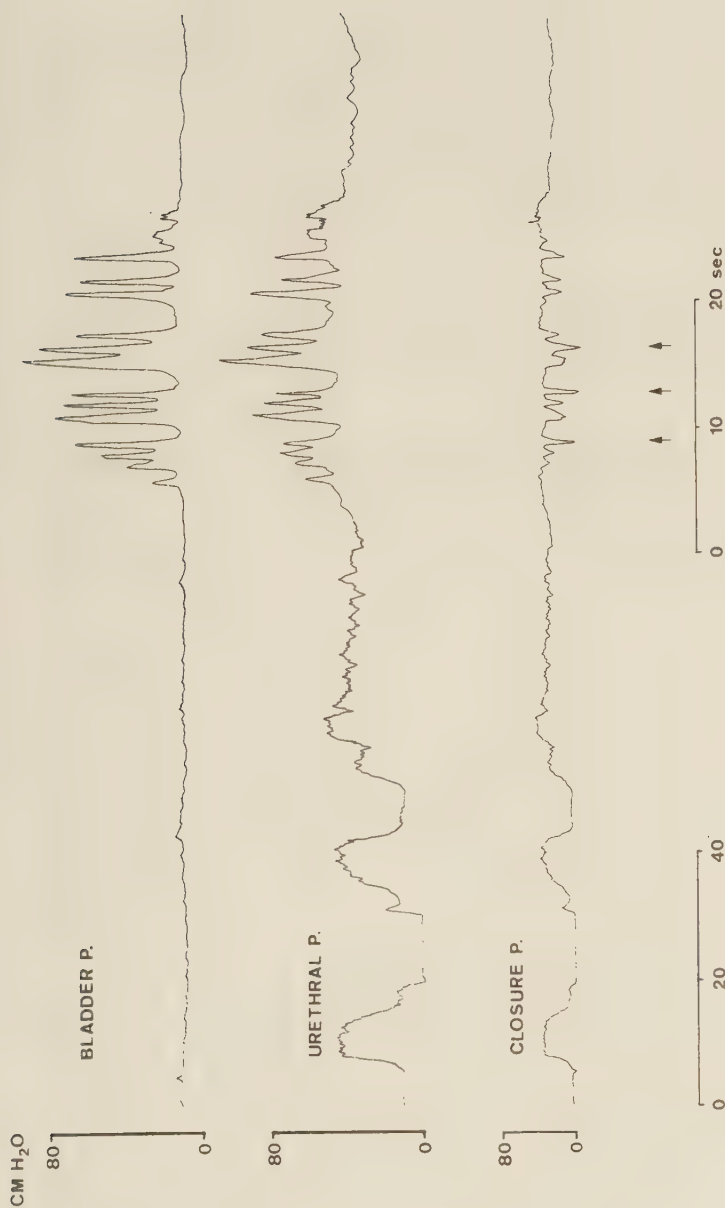


Fig. 2. Urethral pressure profile and simultaneous urethro-cystometry in supine position of 25-year old, Para-I, 16 weeks pregnant woman. Bladder content 200 ml (37°C). Urethral closure pressure negative at repeated coughs with simultaneously urine leakage. Cough indicated by arrows at points where closure pressure reached a negative value. Note also that coughs were provoked when the receptor (R_2 , Fig. 1) recorded the maximal intraurethral pressure.

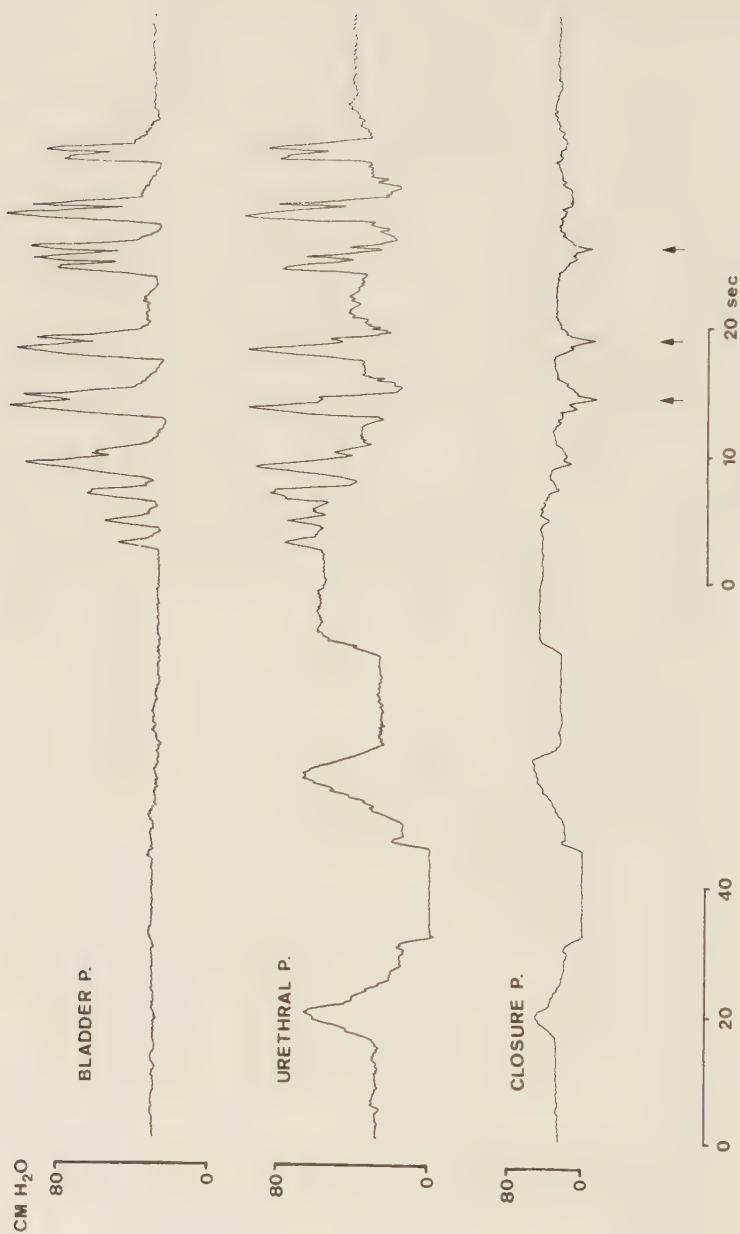


Fig. 3. Urethral pressure profile and simultaneous urethro-cystometry in supine position of the same patient as in Fig. 2 at 38 weeks of pregnancy.

RESULTS

Pressure measurement results are shown in Tables I, II, and III.

As shown in Table I no significant increase took place in the absolute length of the urethra during pregnancy. Neither was there any significant change in the functional length of the urethra (Table I, II). As Table III indicates, there was no significant change in the maximum urethral pressure, which showed a slight increase toward the end of the pregnancy, from 54 cm H₂O to 62 cm H₂O in the supine position, and from 75 cm H₂O to 78 cm H₂O in standing. Bladder pressures recorded in the supine position increased significantly during pregnancy, from 12 cm H₂O to 21 cm H₂O - $p < 0.001$.

The urethral closure pressure in the standing position decreased slightly but significantly ($p < 0.05$) during the pregnancy (Table III). This decrease was not statistically significant in the post partum recording.

The position of the maximum pressure zone of the urethra changed by only 1 to 2 mm during pregnancy (Tables I, II).

No detrusor or urethral instability was observed among the 12 patients examined.

DISCUSSION

Enlargement of the uterus during pregnancy places an added burden upon the surrounding organs in the pelvis minor, particularly upon the bladder (1). To compensate the increased bladder pressure we have found that among healthy continent women a positive physiological increase of both urethral pressure and urethral length occurs during pregnancy (1). No such increase appears to have taken place among the stress incontinent pregnant women investigated in the present study (Table II).

Earlier studies have provided evidence of low urethral pressure in nonpregnant women with stress incontinence (4-10). In the current study we found urethral pressure to be considerably lower in all incontinent pregnant women compared to the previously investigated continent pregnant females (1) (Table II).

Among the stress incontinent pregnant women bladder pressure increased from 12 cm H₂O in the first trimester to 21 cm H₂O in the third. This increase in bladder pressure places added demands upon the closure ability of the urethra if continence capability is to be maintained under stress. As shown in Table II the urethral closure pressure among the stress incontinent pregnant women was un-

Table 1. Stress incontinent pregnant - supine position.

Mean values and standard deviations at registrations 1, 2 and 3, and statistical significance between the first and second, and between the first and third recordings, respectively.

Parameters recorded	Recording 1 12th-16th week of pregnancy	Recording 2 38th week	Statistical significance	Recording 3 5-7 days after childbirth	Statistical significance
Absolute length of urethra, mm	32.0 ± 5.11	32.0 ± 5.35	NS	30.0 ± 4.26	NS
Functional length of urethra, mm	25.5 ± 3.42	24.7 ± 3.11	NS	23.2 ± 2.88	NS
Maximum urethral pressure, cm H ₂ O	54.0 ± 10.32	62.0 ± 11.93	p ≤ 0.001	49.0 ± 8.01	p ≤ 0.001
Bladder pressure, cm H ₂ O	12.0 ± 4.09	21.0 ± 4.61	p ≤ 0.001	8.0 ± 2.07	p ≤ 0.01
Closure pressure, cm H ₂ O	42.0 ± 9.76	41.0 ± 10.44	NS	41.0 ± 7.13	NS
Location of maximum pressure point of the urethra related to internal meatus	12.0 ± 1.87	12.0 ± 2.38	NS	11.0 ± 1.55	NS

NS: not significant

* statistical significance according to Student's t test for paired observations

Table II. Comparison between healthy continent pregnant women¹⁾ and stress incontinent pregnant women - supine position

Mean values and standard deviations and statistical significance between continent and incontinent pregnant women, 3 registrations in supine position. * (Recording 1: 12th to 16th week of pregnancy; recording 2: 38th week of pregnancy; recording 3: 5-7 days after parturition.)

Parameters recorded	Recording	Continent females	Incontinent females	Statistical significance
Absolute length of urethra, mm	1	36.3 ± 5.13	32.0 ± 5.11	p ≤ 0.05
	2	43.0 ± 6.34	32.0 ± 5.35	p ≤ 0.001
	3	32.0 ± 3.61	30.0 ± 4.26	NS
Functional length of urethra, mm	1	30.3 ± 4.63	25.5 ± 3.42	p ≤ 0.01
	2	35.1 ± 5.12	24.7 ± 3.11	p ≤ 0.001
	3	27.6 ± 3.69	23.2 ± 2.88	p ≤ 0.01
Maximum urethral pressure, cm H ₂ O	1	70.0 ± 14.94	54.0 ± 10.32	p ≤ 0.01
	2	93.0 ± 17.29	62.0 ± 11.93	p ≤ 0.001
	3	69.0 ± 14.29	49.0 ± 8.01	p ≤ 0.001
Bladder pressure, cm H ₂ O	1	9.0 ± 2.94	12.0 ± 4.09	NS
	2	20.0 ± 3.03	21.0 ± 4.61	NS
	3	9.0 ± 2.41	8.0 ± 2.07	NS
Closure pressure, cm H ₂ O	1	61.0 ± 13.59	42.0 ± 9.76	p ≤ 0.001
	2	73.0 ± 17.51	41.0 ± 10.44	p ≤ 0.001
	3	60.0 ± 14.41	41.0 ± 7.13	p ≤ 0.001
Location of maximum pressure point of the urethra related to internal meatus	1	14.0 ± 1.60	12.0 ± 1.87	NS
	2	16.0 ± 2.28	12.0 ± 2.38	p ≤ 0.001
	3	14.0 ± 1.46	11.0 ± 1.55	p ≤ 0.001

1) Ref. 1 NS: not significant

* statistical significance according to Student's t test for paired observations

Table III. Recording of six stress incontinent pregnant women in both supine and standing positions

Mean values and standard deviations and statistical significance between supine and standing at recordings 1, 2, and 3, for six patients examined in both supine and standing positions. *

Variable	Recording ¹⁾	Supine	Standing	Significance
Absolute length of urethra, mm	1	34.4 ± 4.63	35.4 ± 5.31	NS
	2	34.7 ± 4.67	34.7 ± 5.00	NS
	3	30.7 ± 3.26	32.0 ± 4.19	NS
Functional length of urethra, mm	1	26.7 ± 3.93	25.0 ± 5.62	NS
	2	25.7 ± 3.67	23.7 ± 5.85	NS
	3	23.0 ± 2.75	22.7 ± 3.50	NS
Maximum urethral pressure, cm H ₂ O	1	54.0 ± 10.56	75.0 ± 9.01	p ≤ 0.01
	2	61.0 ± 10.70	78.0 ± 9.43	p ≤ 0.001
	3	51.0 ± 6.35	70.0 ± 6.30	p ≤ 0.001
Bladder pressure, cm H ₂ O	1	14.0 ± 5.50	39.0 ± 2.39	p ≤ 0.001
	2	20.0 ± 4.84	40.0 ± 3.03	p ≤ 0.001
	3	9.0 ± 1.66	27.0 ± 0.00	p ≤ 0.001
Closure pressure, cm H ₂ O	1	40.0 ± 8.72	36.0 ± 9.22	p ≤ 0.05
	2	41.0 ± 8.67	38.0 ± 10.46	p ≤ 0.05
	3	42.0 ± 5.14	43.0 ± 5.08	NS
Location of maximum pressure point of the urethra related to internal meatus	1	12.4 ± 2.33	12.0 ± 2.19	NS
	2	12.0 ± 2.82	11.0 ± 3.03	NS
	3	10.7 ± 1.63	10.4 ± 1.50	NS

1) Recording 1: 12th to 16th week of pregnancy
 Recording 2: 38th week of pregnancy
 Recording 3: 5-7 days after parturition

NS: not significant
 * statistical significance according to Student's t-test for paired observations

changed low during the entire period of the pregnancy (42 cm H₂O in weeks 12 to 16, and 41 cm H₂O in week 38). No compensating increase took place among these patients as was the case among the continent pregnant women examined earlier (1), where an increase from 61 cm H₂O in week 12 to 73 cm H₂O in week 38 was registered. These differences between incontinent and continent pregnant women are statistically significant: $p \leq 0.001$ (Table II). The changes of position from supine to standing among the incontinent pregnant women led to a reduction of the closure ability of the urethra (Table III), which was statistically significant ($p \leq 0.05$).

Furthermore the urethral closure pressure under stress was negative in all incontinent pregnant women (Fig. 2 and Fig. 3) but positive in all the continent pregnant women investigated earlier (1).

The importance of the length of the urethra with respect to continence and incontinence in women has been discussed earlier in the literature. In a comparative study of continent and incontinent women in 1960, Lapidus found a prevalence of short urethras among patients with stress incontinence (4). In 1978, Henriksson found that both the absolute and the functional lengths of the urethra were shorter in stress incontinent patients in comparison with continent women (10). Toews (7), and Edwards (8), on the other hand, found no correlation between short urethras and the incidence of stress incontinence. Neither in operations for stress incontinence has it been possible to definitely establish any significant permanent elongation of the urethra after surgery (11). In our earlier studies of normal continent pregnant women (1), we registered increases in the absolute and functional lengths of the urethra by 7.5 and 5 mm, respectively, from the 12th to the 38th week of pregnancy (Table II). Among the stress incontinent women examined here, there was no increase in either the absolute or the functional length of the urethra (Table I). Among healthy patients, therefore, it appears that under physiological circumstances as, for example, pregnancy, in contrast to surgical measures for incontinence (11), a physiological compensating increase in both urethral pressure and length assures that continence is maintained. The absence of such a compensating increase in urethral pressure and length among the incontinent pregnant women investigated here leads to a successively reduced urethral closure pressure as the pregnancy progresses, with increased leakage of urine as a result.

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